This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 454242

ANALYSIS

OF

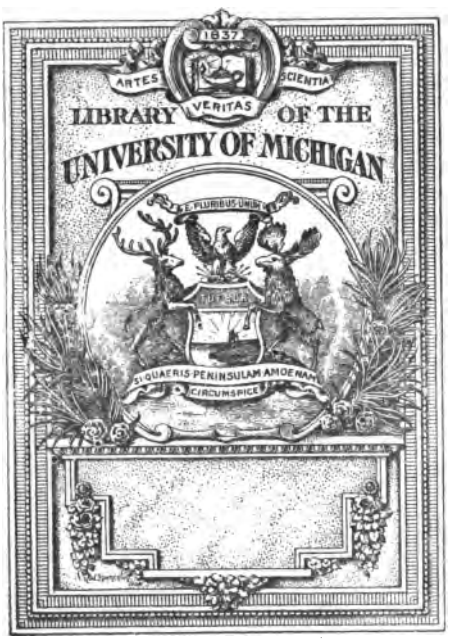
Milk, Condensed Milk,

AND

INFANTS' MILK-FOODS.

Dr. J. GERBER.

Printers, Lithographers,
Bookbinders,
95, 97, Fulton St., N. Y.



SF
253
.G362

CHEMICAL AND PHYSICAL ANALYSIS

—OF—

MILK, CONDENSED MILK,

—AND—

INFANTS' MILK-FOODS,

WITH SPECIAL REGARD TO

HYGIENE AND SANITARY MILK INSPECTION.

A Laboratory Guide, developed from Practical Experience,

INTENDED FOR

CHEMISTS, PHYSICIANS, SANITARIANS, STUDENTS, ETC.

By Dr. NICHOLAS GERBER,

Manager of the American-Swiss Milk Product Company (Limited) in New York; Member of the Chemical Societies of Berlin, New York, Paris, etc.

Translated from the Revised German Edition, and Edited by

Dr. HERMANN ENDEMANN,

Editor of the Journal of the American Chemical Society; Member of the Chemical Societies of Berlin, New York, etc., etc.

ILLUSTRATED BY 19 PLATES.

NEW YORK, 1882.

Entered according to Act of Congress, in the year 1882, by the proprietors,
DR. NICHOLAS GERBER, of Little Falls, N. Y.,
DR. HERMANN ENDEMANN, of 33 Nassau St., New York City,
in the Office of the Librarian of Congress, at Washington.

LEHMAIER & BRO. PRINT,
95, 97, FULTON STREET, N. Y.

EDITOR'S PREFACE.

In preparing this book for the English-speaking public, the undersigned desires to state that he has undertaken this task for the purpose of supplying a long-felt want. Most books published of late contain merely a collection of all the methods of analysis, or the selection of a number, put side by side without criticism.

The book in its present shape is a laboratory guide, which enables even beginners, and all such who cannot make the subject of milk analysis a speciality, to cope with this otherwise complicated task.

The selection of the proper method of analysis is taken off their hands and has been supplied by a man of practical experience, who has for many years made this subject a specialty.

Even chemists will find this book valuable, the more so as they are the best able to judge the advantages derived from the proper selection of the method adapted for the execution of an analysis.

The original has been carefully revised and many of the plates which illustrate the work have been substituted by better ones taken from the best publications on this subject, while others not contained in the original have been added.

H. ENDEMANN, Ph.D.

New York City, January, 1882.

237143

PREFACE.

The undersigned has been engaged, scientifically and practically, in the dairy industry in all its branches for a number of years, and thus has had, frequently, occasion to seriously feel the want of a uniform method of analysis for milk and its products, which would not only satisfy practical wants, but would also possess scientific accuracy.

The author has made it his task to present in this small volume a short and exact method of analysis for the examination of the various milks and infants' milk foods, and hopes to soon complete his undertaking by the issue of a similar volume which shall comprise the examination of the other milk products and such other substances as are employed in the dairy industry.

As may be seen by the contents, undersigned has not endeavored to criticise the various older methods, as yet generally in use, as this would have been beyond the range of his self-imposed task.

Moreover, there is no want of such books. Undersigned therefore refers to those previously published by Vieth, Radenhausen and himself.

It is a peculiar fact, that even in the latest chemical, medical and pharmaceutical works, old and abandoned methods are continually republished, the authors considering it apparently unnecessary to test them for their reliability.

Likewise, in the adducing of average figures regarding the composition of milk, these authors seem to be prepossessed in favor of the oldest and least exact investigations, while they neglect the more exact and, therefore, more valuable examinations of the present period.

This copying without examination (book manufacturing) is especially dangerous in analytical chemistry, and more so if the results must stand test before a court of justice, which in examinations of this kind is frequently required.

The position of an expert who has employed acknowledged inaccurate methods for his examination, is certainly not an enviable one.

The author of this small volume has therefore collected therein, for the first time, those methods which are acknowledged as being the best for scientific and practical purposes.

They excel the methods known before 1877.

1st. For their greater accuracy.

2d. For greater simplicity.

3d. For cheapness and economy of time.

The views expressed in this book no doubt may be modified in time, and undersigned will, therefore, at all times, be pleased to receive suggestions from others.

DR. NICHOLAS GERBER,

Manager of the American Swiss Milk Product Co. (Limited),

New York City.

LITTLE FALLS, N. Y., January, 1882.

CONTENTS.

PAGE.

Introduction..... 1

NORMAL COWS' MILK.

General Definition..... 3
Colostrum..... 3
Market Milk..... 3

Physiological and Other Causes Influencing the Secretion.

Period of Lactation..... 3
Age of Cow..... 4
Cows in Heat..... 4
Race and Individuality..... 4
Food and Treatment..... 5
Seasons..... 5
Influence of Temperature..... 5
Influence of Weather..... 5
Exercise..... 5
General Physical Properties..... 6
Chemical Constituents..... 6
Composition of other Milk Compared with Cows' Milk..... 8

PHYSICAL ANALYSIS OF MILK.

Color—Normal..... 9
Red..... 9
Yellow..... 10
Blue..... 10
Consistency—Normal..... 11
Watery..... 11
Colostrum..... 11
Phlegmy and Stringy.. 12
Sandy..... 12
Odor—Normal..... 13
Aromatic..... 13
Putrid..... 13
Medicinal..... 13
Taste—Normal..... 13
Bitter..... 14
Medicinal..... 14
Putrid..... 14
Sour..... 14

Microscopical Examination.

PAGE.

Normal Milk (with plate)..... 14
Butter Globules..... 14
Colostrum (with plate)..... 15
Pus and Epithelial Cells (with plate). 16
Lower Organisms..... 16

Specific Gravity.

Definition..... 17
Apparatus for Its Determination... 17
Weighing in a Flask (Pycnometer) (with table.)..... 18

CHEMICAL ANALYSIS OF MILK.

General Rules..... 21
Reaction of Milk..... 22
Determination of Water and Solids. 22
Determination of Ashes..... 23
Determination of Phosphoric Acid. 23
Determination of Albuminates and Fat (with plate)..... 24
Determination of Milk Sugar..... 27

ABNORMAL COWS' MILK.

Colostrum..... 30
Poisoned Milk..... 31
Milk Containing Medicines..... 33
Milk as the Cause of Disease (2 plates) 33
Typhus..... 34
Scarlatina..... 34
Tuberculosis..... 34
Anthrax..... 35
Aphtha epizootica (with plate) 35
Influence of Food, etc...... 37
Potato Distillery Swill..... 37
Brewers' Grains..... 38
Milk in Fermentation..... 38
Pus..... 38
Mucus..... 38
Adulteration of Cows' Milk..... 38
Watery Milk..... 39
Normal Market Milk..... 40
Sour Milk..... 41
Foreign Substances..... 41
Preservatives..... 42

MILK OF OTHER ANIMALS.

PAGE.

Goats' Milk 44
Sheep's Milk 44
Asses' Milk..... 45
Mares' Milk 45

CONDENSED AND PRESERVED MILKS.

Condensed Milk, with Sugar 47
Physical Analysis 48
Chemical Analysis..... 49
Other Milk Preserves..... 50
Hygienic Demands..... 51

WOMAN'S MILK.

Various Influences upon the Secretion..... 52
Taking the Sample..... 55
Physical Examination (2 plates) 55
Chemical Analysis..... 57
Milk from the Breasts of Newly-born Infants..... 60

INFANTS' MILK FOODS IN POWDER.

History, Definition..... 61
Physical Properties..... 61
Microscopical Examination (5 plates). 62
Chemical Analysis..... 65
Determination of Water..... 65
" of Ash and Phosphoric Acid..... 66
Determination of Fat 66
" of Soluble Carbohydrates 67
Determination of Insoluble Carbohydrates..... 68
Determination of Albuminates. 69
Reports on Milk Foods..... 69

INFANTS' MILK FOODS IN POWDER—*Continued.*

PAGE.

Hygienic Demands of the Manufacturers 70

GOVERNMENT CONTROL OF THE MILK SUPPLY..... 73
Determination of Specific Gravity.... 76
Quevenne's Lactodensimeter and the Lactometer (2 plates)..... 78
And 2 tables..... 81 and 82
Examination of Skimmed Milk 83
Stable Test.... 84
Estimation of the Quality of Milk by the specific gravity.. 85

Determination of the Fat (with plate and table)..... 85

Properties of Normal Cows' Milk and Market Milk..... 92

The Aim of Governmental Control of the Quality of the Milk Supply..... 92

General Rules for a Rational Milk Inspection 94
In Cities..... 94
In the Stable..... 96

Proposition stating the Main Points for an Ordinance Regulating the Sale of Milk in Large Cities..... 97

Propositions for Regulations Governing Producers of Milk and Milk Dealers.....98

LIST OF APPARATUS AND CHEMICALS REQUIRED FOR THE ANALYSIS OF MILK and INFANTS' MILK FOODS..... 100

INTRODUCTION.

Of all articles of food, none requires so much of our attention as milk. While it engages the scientist on account of its relation to physiology and pathology, the public are interested in milk by the place it occupies as a food of so general application, and by the fact that it forms an important article of commerce and a base for manifold industries. Cows' milk, and of late, infants' milk-foods and condensed milk, are of more special interest by the fact, that in the case of an insufficient or wholly wanting supply of breast milk, they are destined to form, for a considerable period of time, the sole food for infants. We should, therefore, be well acquainted with the quality of these articles as they reach the consumer.

To insure a supply of healthy and unadulterated food, the governments of many countries have passed laws for the punishment of adulterations, and in order to detect them, have taken the examination of the various food substances in hand. Milk, being more exposed to adulteration than many other foods, has of late received a considerable share of this attention.

The control which a government exerts, protects the public against fraud by preventing the sale of goods of inferior value at high prices; but more important is the protection which, by government interference, is gained for the health of the consumer by the absolute prevention of the sale of specifically altered, spoiled and adulterated milk. The poorer and working classes, and especially the children, suffer most, if the milk is not of the best quality.

Chemical analysis, even if carried out according to the best approved methods, would not bring us nearer to a satisfactory solution of this question, unless exact science has thoroughly investi-

gated this field, and has, based upon such investigation, determined the limits of the composition of a normal food. Without this, the position of an expert before a court of justice would be untenable.

The examination of the milk differs according to the question which is to be decided. It may be made to ascertain the relative quantities of the normal constituents of milk, or to determine the admixture and nature of foreign substances which may, or may not, be dangerous to the health of the consumers.

Each chemical examination is preceded by an examination with the senses—eye, smell and taste. Hereby many admixtures and qualities of milk may be directly ascertained, which, for the following chemical examination, may not only furnish hints, but which may serve to corroborate the results obtained by it.

The physiological part of the milk question has been included for the reason that in cases before the courts such questions frequently arise, and because the knowledge of them will aid in the formation of a more correct opinion.

To facilitate the examination of milk and milk products, a number of plates from microscopic objects have been introduced into the text.

The chemical and physical analysis of infants' milk-foods and their hygienic value, has in no previous work been treated as thoroughly. The method of analysis given is based upon the exact investigations made by Dr. P. Radenhausen and the author, and is given in this work in an improved shape. The author desires to recommend to the consideration of the medical profession the chapter entitled, "Hygienic demands upon the manufacturers of infants' milk-foods." Humanity demands that we know and examine which foods should be recommended and can be relied upon. Much hardship and sickness of mankind can be prevented, if by rational food the organism, especially of infants, be strengthened. The author sincerely desires that the contents of this book will not fail to improve our knowledge of food hygiene, and thus fulfil the expectations with which it has been written.

NORMAL COWS' MILK.

GENERAL DEFINITION.

MILK is the secretion of the mammary glands, in which it is produced by certain processes of diffusion from the blood, accompanied by a dissolution of the gland cells. Lactation commences a few days after birth, and lasts for a period of time, the length of which depends on various circumstances. C. Von Voit says: "Milk consists of liquified cells. All mammals are, therefore, carnivoræ, for they sustain themselves by consuming a portion of the body of their mother."

Colostrum: The first milk yielded by a cow, either before, or from the fourth to seventh day after calving, is called 'beastings,' or '*colostrum.*'

Market milk is generally the milk of several cows mixed. For the examination of the milk, as it reaches our markets, this is a point of great importance—many irregularities, frequently met with in the milk of single cows, being thereby compensated.

The substances composing milk are for all mammals essentially the same. So is the general character of the milks. The difference of the various milks consists, therefore, only in the respective quantities in which the constituents are present, as also in taste, flavor and color.

Physiological and other Causes Influencing the Secretion.

The period of lactation generally lasts three hundred days, one cow giving during this time from six to ten quarts of milk per day. When the animal ceases to give milk, we say that it stands dry.

The following circumstances are of influence on lactation:

Age of cow: When a cow has its first calf, it does not produce the maximum quantity of milk, but the quantity increases from year to year until a certain limit is reached, when, with further increasing age, the quantity is reduced, at first slowly and more quickly later on.

The age to which it pays to keep cows for milking differs according to individuality, race and treatment. It is generally accepted that cows are the most profitable from their third to their tenth year.

Cows in heat: We know but little of the changes which occur in milk at the return of the periods when cows get in heat.

From the feeding experiments made by G. Kuehn and Fleischer, a characteristic change of the milk, during these periods, cannot be deduced. Such milk, it has been stated, will sometimes curdle on boiling. A normal course of this process, which lasts but a few days, should not influence normal lactation for any length of time.

It may be remarked that also cows which have undergone the process of castration, may produce milk. It is, however, not considered profitable to keep such cows longer than two years. They fatten up rapidly, and their milk-producing qualities suffer in consequence.

Race and individuality: Good milk-producing qualities depend principally on a strong and healthy development of the udder. A defect in this can never be remedied by the best and most nutritious food. The yield and quality of the milk depends directly on individual properties of the animal and, therefore, also on its race.

Comparative investigations regarding the yield and quality of the milk of different races have freqnently been made, but they are incomplete and little trustworthy. They have either been undertaken with but few animals for a longer period, or if really on a large scale, but for a short period. In some cases select stock has been observed for longer periods. Average figures deduced from such incomplete and heterogeneous observations are, therefore, of little value. The yield and quality of the milk of various races and breeds of cattle, cannot be determined without the collection of copious and well selected statistics in the countries of which these cattle are indigenous. Few investigations have been made to which chemistry has contributed as largely as it should have done.

Food and treatment: To keep the production of milk during the whole period of lactation in a satisfactory state, good housing and treatment, and food answering the circumstances, as regards quantity, volume, preparation and chemical composition, are requisite.

It may be regarded as a fact, that the quantities of milk and butter are increased with the amount of nitrogenous material in the food. Uniformity of treatment and food are to be recommended, and sudden changes in this regard be avoided, since experience has proved that they are invariably followed by disadvantageous influences upon the secretion of milk. The production of milk is greatly fostered by healthy water of an even temperature, neither too high nor too low, charitable treatment of the cattle, and punctuality in attending to their wants.

Seasons: The yield of milk differs with the changes of weather and food in the several seasons. Most, but often also thinnest, milk is produced during the spring, on account of the food which then consists mainly of young luxurious herbs. The more nourishing after-growths on the meadows and fields during summer and fall, as also the dry food during winter, are the cause of a smaller yield of milk which, however, is richer.

Influence of temperature: The yield of milk of the cows differs with the geographical latitude. From this alone we may assume that the temperature exerts a decided influence. An average annual temperature of 15° C. is considered to be the most advantageous. Too high temperatures (in the stable) debilitate and predispose the cows to colds, influence disadvantageously the yield of milk, and sometimes even its quality.

Influence of weather: Rain, humidity of air and winds doubtless exert an influence on the general well-being and the various physiological processes. Exact investigations as regards the influence of these meteorological phenomena on yield and quality of milk, have not yet been made.

Exercise: Moderate exercise in the open air and on the pasture is advisable. Hard work and long journeys diminish yield and quality of milk. Milk of such cows is apt to curdle on boiling.

The *constitution* of the animal is reproduced in the milk it yields. The milk of stronger animals is, therefore, on the average,

richer than the milk from the weaker. The use of *inferior food* and *unhealthy water*, and *certain diseases*, cause also the production of an inferior milk. Particulars regarding this will be given in the chapter on "Abnormal cows' milk."

General Physical Properties.

Milk is an opaque, white or more or less yellowish fluid. Between the fingers it feels greasy. It has a weak, mild, sweetish taste, and flavor to correspond. The microscope reveals the presence of innumerable small globules suspended in a pelucid fluid. Sometimes epithelial cells, gland cells and lower organisms may be recognized. The specific gravity varies from 1.025 to 1.038.

Chemical Constituents.

I. The ***main constituent of milk is water,*** of which, on the average, 87.5 per cent. is present.

II. The ***albuminates*** of milk are, according to the latest investigations of Danilewsky and Radenhausen, as follows:

1. ALBUMEN, probably identical with blood albumen.
2. PROTALBUMENS, which Danilewsky obtained some time since by peptonizing various albuminates with alkali and pancreatine. These give to casein its acid character. Albumen and the protalbumens together form the so-called casein, which is, therefore, not a single body but a mixture.
3. ORROPROTEIN, which is an albumen with albuminoid characteristics.
4. SYNTO-PROTALBUMENS, which, according to Danilewsky, are obtained from albuminates by the action of acids and pepsin.
5. PEPTONES, or digested albuminates, were found by D. and R. in the serum of coagulated milk, together with the extractive substances.

   Milk contains, therefore, according to Danilewsky and Radenhausen, large quantities of incompletely digested albuminates which, according to their characteristics, were called *protalbumens* and *synto-protalbumens.*

The *protalbumens* are acid bodies, soluble in 50 per cent. alcohol, insoluble or little soluble in water. At ordinary temperature they saturate alkalies but not acids.

The *synto-protalbumens* have a neutral reaction. At ordinary temperature they do not unite with alkalies, but mineral acids. They act, therefore, as bases. They are insoluble in water, soluble in hot 50 per cent. alcohol, from which solution they may be obtained on cooling. The main constituent of the *albumen* of former investigation, is identical with the stroma albumen which envelopes the butter globules.

These investigations give us an entirely new picture of the constitution of milk. The hitherto known casein, albumen and lacto-protein, do not exist, and these names should, therefore, not be used in reporting the results of the analysis; instead, it is better to class them under the general denomination of "albuminates."

III. The ***milk-fats*** appear as minute globules which can be recognized merely with the aid of the microscope. Each of these globules is surrounded by a thin film of stroma albumen (not casein). Their diameter varies considerably. Specific gravity and melting point vary likewise with race and quality.

The fats are triglycerides, derived mainly from *stearic, palmitinic and oleic acids;* aside from these the following are to be mentioned: *myristine, butine, butyrine, capronine and capryline.* The chemical composition varies considerably with the food on which the animal is kept, likewise the color, which, during the summer is yellow, while during the winter it appears more white. Fresh milk-fat is a semi-fluid mass of faint taste and odor.

IV. ***Milk sugar*** ($C_{12}H_{22}O_{11} + H_2O$) crystallizes when pure in rhombic prisms, which are not changed when kept in dry air. It feels hard and gritty between the teeth. It is insoluble in absolute alcohol and ether, soluble in 6 pts. of cold, and 2.5 pts. of boiling water. Its taste is only slightly sweet. Its specific gravity varies from 1.543 to 1.548. In the polariscope it shows birotation.

V. The ***Milk ashes*** consist, according to Fleischmann, in the average, of

Phosphoric anhydride,	(P_2O_5)	28.31
Chlorine,	(Cl)	16.34
Lime,	(CaO)	27.00
Potassa,	(K_2O)	17.34
Soda,	(Na_2O)	10.00
Magnesia,	(MgO)	4.07
Iron sesquioxide,	(Fe_2O_3)	0.62
		103.68
Deduct for O corresponding Cl,		3.68
		100.00

The quantity of salts in the milk ranges from 0.4 to 0.8 per cent. They contain generally all those nutritive salts which have been taken with the food.

VI. The ***gases of milk*** are carbon-dioxide, nitrogen and oxygen, the first predominating. They are of little importance.

VII. The ***extractive substances:*** They have been found in small quantities in the milk, and include the following substances: urea, kreatinine, leucine, tyrosine and lecithine.

VIII. In small quantities, ***coloring substances,*** and such which give to milk its characteristic flavor. They vary with the season and food, and are met with in larger quantities during the summer season.

Composition of Other Milks compared with Cows' Milk.

Milks from other animals differ from cows' milk in composition according to the position occupied by the animals in the zoological system, and according to their food (herbivora or carnivora).

The following tabulated statement gives average values derived from a series of exact analyses of normal milks:

Species.	Sp. gr.	Water.	Salts.	Albumen.	Fat.	Sugar of Milk.
White woman.....	1.025–1.035	88–90	0.20–0.50	2.0–4.0	2.0–4.0	4.0–6.0
Negro "	1.025–1.037	86–90	0.30–0.75	3.0–4.0	4.0–5.0	5.0–6.0
Milk of single cows..	1.025–1.038	86–89	0.50–0.75	3.5–5.0	3.0–4.5	3.5–5.0
Mare	1.031–1.036	90–92.5	0.25–0.50	1.5–3.0	0.5–1.5	4.5–6.5
Ass.....	1.030–1.036	89–92	0.25–0.50	1.5–3.0	1.0–2.5	4.5–6.0
Goat.....	1.028–1.036	85–87	0.50–0.75	4.0–6.0	3.5–5.0	3.5–5.5
Sheep.....	1.034–1.042	80–85	0.50–1.25	4.0–6.5	4.0–7.0	4.0–6.0
Hog.....		82–85	0.75–1.25	5.0–7.0	5.5–7.0	2.0–5.0
Camel	1.035–1.042	85–87	0.50–0.75	3.0–4.0	2.5–3.5	5.0–6.5

Of the milk of other animals only a few, and then often incomplete analyses of doubtful value could be found; their mention has therefore been omitted.

Physical Analysis of Milk.

COLOR.

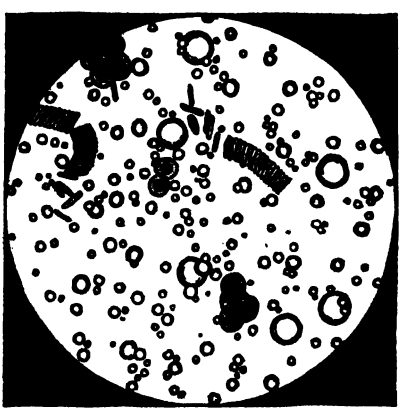
Normal: Milk in its normal state is opaque white to yellow. During winter it is more white, while in summer the color is more or less yellow, produced by the richness of the food in chlorophyll. Plants containing certain coloring substances, may impart certain hues to the color of milk. Peculiarities of color may, however, be produced by other causes.

Red: Red milk is mainly caused by a general diseased condition of the cow, and has been found in cases of anthrax, as an accompanying symptom of red murrain, and after the use of acrid and resinous remedies.

Such milk contains many blood corpuscles and gives on standing, a sediment.

Milk appears sometimes irregularly colored, the color appearing in streaks or attached to coagulated masses, which collect rapidly at the bottom of the vessels. The occurrence of such milk is frequently confined to certain parts of the udder, and is then caused by congestion, inflammation, and mechanical injuries inflicted upon the udder.

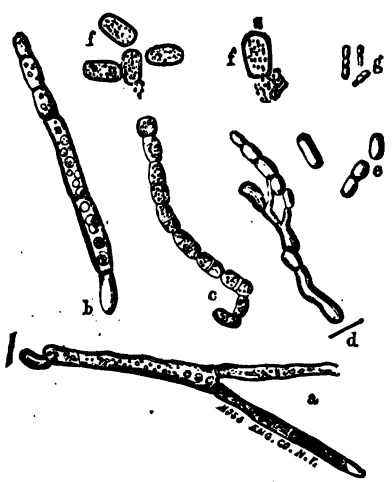
Detection: Blood corpuscles are easily detected by the microscope. They are recognized by their yellowish color and their shape. They present themselves as small disks, slightly indented in the centre. This can best be seen on single corpuscles. They are frequently united, forming bodies similar to rolls of specie. The accompanying cut represents milk containing blood corpuscles.



Milk containing blood will, on boiling, change its color from red to brown, since hæmoglobine is decomposed on the application of heat. Rennet and madder will color milk uniformly, and the color thus produced does not undergo change on boiling.

Yellow: The yellow color may be produced by certain vegetable pigments. It is said to also accompany certain changes which are characterized by the formation of stringy, skinny and lumpy coagula, which sink to the bottom on standing. The supernatant milk appears opalescent and stringy. This color is also observed in jaundice. Cause: congestion and inflammation of the udder.

Blue: A blue color in milk has rarely been observed at the time of milking, unless it be produced by blue vegetable pigments. The milk is in this case uniformly colored. Milk may, however, after some time turn blue under the influence of certain ferments. On the surface of the milk or the cream, beautiful indigo-blue spots appear which gradually enlarge. After some time the color ceases to increase, and then, even with the naked eye, the growth of fungi can be observed. Already long before this the microscope shows the presence of mycelium, vibrios and bacteria in such milk. The original cause of this milk infection has been traced to the growth of a certain fungus described by Fuerstenberg (see cut), whereby the constituents of the milk are decomposed, giving rise, as some believe, to the formation of aniline blue (triphenylrosaniline).



This has as yet not been established as a certainty. Spectroscopic investigations, however, point to a dye-stuff standing in near relation to the aniline dyes. When and why this fungus makes its appearance is not known. This milk disease can be banished by extreme cleanliness and the use of disinfectants.

As to the duration, appearance and propagation of this abnormity in one place, or in comparison with other places, no rules could be established. It has likewise been found that the use of preventatives was not always followed by the same results.

It is therefore easily understood why so many theories as to its cause should be given. While one looks for the cause to the cow, others find it in the food, until we know now that this abnormity is produced by a ferment. (Peterson, *Forschungen*, 1881, p. 78.)

CONSISTENCY.

Normal milk: Normal whole milk is a fatty, homogeneous, opaque liquid, which is always heavier than water. Its consistency is influenced by the milking, the first milk being always more watery than the last. This circumstance is of considerable importance when an examination is to be made of the milk furnished by a certain animal, or all such as are housed together or supply a dairy. The following abnormal conditions have been observed:

Watery milk: Watery milk is strikingly fluid and of a bluish-white color. It is poor in solids, especially fat, and its specific gravity is below the normal.

Causes: Indigestion, unsuitable food and housing. Indigestion may be caused by the animal getting in heat. This normal existence of watery milk must be well considered in milk inspection. It will rarely affect more than a few cows in the same stable at one time, and if such milk is mixed with the normal milk of the other cows, its characteristics, notably its low specific gravity, will be compensated. It can therefore but rarely be the cause of serious complaints.

Colostrum: Colostrum, by milkmen and farmers called beastings, is decidedly phlegmy and glutinous. It possesses a peculiar stale taste. On boiling, it curdles. Its specific gravity is very high=1.08, it being very rich in solids. This milk is not an article of trade.

Phlegmy and stringy milk shows its characteristics only some time after milking. It is thick and of flat taste, and shows its stringy consistency if it is observed while it runs from the finger after immersion. It creams slowly, and it is difficult to obtain butter from it, which, when obtained, has a disagreeable taste. Investigations regarding this process are incomplete, but it seems that it is produced by some process of fermentation. Phlegmy milk is said to curdle sooner than normal milk, the curd presenting likewise an abnormal appearance and phlegmy consistency.

Such milk is said to infect normal milk. Its occurrence is caused by indigestion, the use of poor and spoiled food, colds, and, according to the latest investigations, also inefficient ventilation of the dairies.

In Norway, Sweden and Finland, an herb, *Pinguicula vulgaris*, is added to the milk as a preservative. It is known to make milk likewise stringy.

Sandy milk: Sandy milk contains solid mineral granules, which are often so large and occur in such quantities, that the teats become clogged.

Fuerstenberg, who examined such milks very thoroughly, distinguishes three kinds of milk stones or galactites.

1. Real galactites consist of small granules, around which amorphous salts of the alkaline earths have formed in concentric layers. They are in shape globular, elongated, and occasionally angular. Their surface is either smooth or rough, and their color whitish to gray. In size they range from the size of a millet grain to the size of a bean.

2. Pseudo galactites are in appearance similar to the former; they consist, however, of a hollow and compact curd of casein, which is covered with crusts of salt.

3. Concrements are amorphous, comparatively large, irregularly shaped masses of organic matter, without concentric structure. Their surfaces are rough white and lustreless like chalk. When brought in water they swell and become soft.

Cause: Food and water, rich in salts of the alkaline earths, especially lime.

Chemical composition, according to Fuerstenberg:

	Galactites.		
	Real.	*Pseudo.*	*Concrements.*
Calcium carbonate	91.03	92.30	17.45
Phosphates of alkaline earths	1.13	2.78	55.98
Fats	1.30	0.93	2.60
Other organic substances	5.40	3.14	18.55
Waters	1.14	0.85	5.83
Specific gravity	2.192	2.281	2.114

ODOR.

Normal: Milk possesses a peculiar odor, especially at the time when it comes from the udder.

This is similar to the exhalation of the skin, and must not be confounded with the milk flavor or aroma. It seems to be a peculiar substance, and not to belong to one of the recognized constituents of milk.

Milk filtered over animal charcoal is said to lose this smell. It is therefore considered a substance for itself.

This animal odor is stronger during the heat of summer than in winter time, and is apt, if present in quantity, to adhere even to the preparations manufactured from milk. Milk should, therefore, be frequently aired to free it from this odor.

Aromatic: The essential oils of certain herbs contained in the food are also easily recognized by the peculiar flavor which they impart to milk.

Putrid: Putrid decomposition of milk has been observed as consequence of untidy handling, keeping, and feeding with tainted food and crude rancid bone dust, which at one time had been recommended as tending to increase the yield of milk. The cream of such milk is off-color, and breaks, in consequence of ascending gas, which contains sulphuretted hydrogen.

Medicinal odor: An abnormal odor in milk may also be caused by the odor of substances contained in food or medicines.

TASTE.

Normal: Normal milk has a mild, sweetish taste. That cows' milk does not taste like goats' milk, is owing to the peculiar odor which is observed when it is tasted.

Bitter: Bitter milk developes its taste only some time after it was milked, and is accompanied by souring. The chemical changes which take place in such milk are not known, but the development of gas seems to indicate a fermentation, the whole being, perhaps, merely an incipient state of putrid decomposition.

Milk is said to become bitter also after the feeding with bitter herbs, like *absynthum.*

Medicinal: Medicines may likewise impart to milk a peculiar taste.

Putrid: The taste of milk in putrid fermentation.

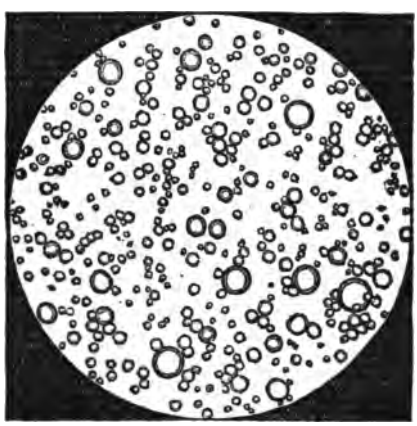
Sour: Milk sours most frequently in sultry weather during the summer. It may also be caused by diseases of the udder, or when the cows have not been completely milked. Such milk curdles when heated.

The Microscopical Examination.

This examination is to determine qualitatively whether a milk is normal, diseased, or partially adulterated. For the construction and use of the microscope we must refer to such works as treat this branch of science as a specialty.

Normal milk: Milk, like blood, is an emulsion containing some substances in solution, while others, the so-called milk globules, are held in suspension, thus producing the color and opacity peculiar to milk.

Butter globules: The butter or milk globules are highly refracting globules, with an average diameter of 0.017 to 0.025 m.m.



They appear with well marked outlines, dark at the edges, and bright in the centre. They are simply fat globules which are prevented from uniting by being immersed in milk plasma, which contains casein in a swelled state. We distinguish three sizes of globules.

1. The *very large*, and comparatively lightest, which, on account of their larger volume, rise first, and form the first cream on the milk. They are said to contain the fats of lowest melting points.

2. The *medium size* form the main constituent of a good milk.

3. The *smallest*, of which good milk contains but few, and poor milk large quantities.

White milk contains more of these butter globules than blue milk.

A normal milk should contain these globules moderately dense; they should be well-formed and separate, and should form the only shaped portion of the milk. Milk of older cows is generally richer in large globules.

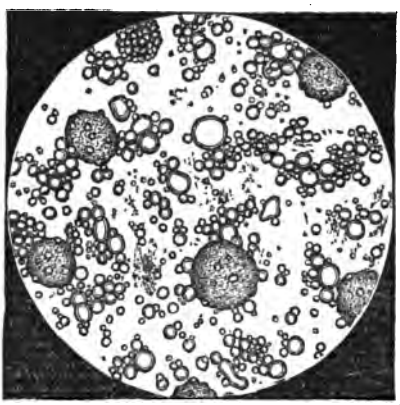
If the majority of the globules is small and poorly shaped, it indicates that the milk is poor in fat, and lacks in nutritive qualities.

Watered and skimmed milk: The *watered milk* contains the fat globules in the same proportion, as far as size is concerned, as they are found in normal milk. The number of globules in the field differs according to the quantity of water added.

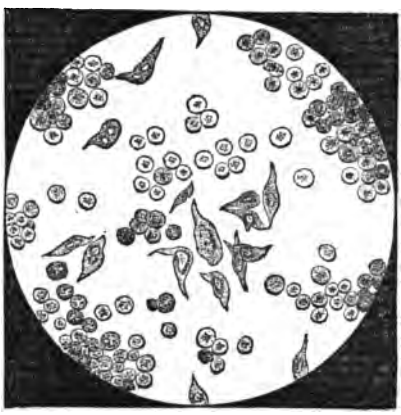
Skimmed milk generally contains none of the larger butter globules, these having been removed with the cream.

Value of microscopical examination: The *value of milk* can never be determined by means of the *microscope.* Author concurs here with Vieth, who says: "The microscopical examination of milk may, under circumstances, furnish valuable indications, if used for the detection of abnormal qualities in appearance or behavior, or the determination of foreign substances added to the milk. As a control for the determination of the fat, it has no more value than other, even the best optical methods."

Colostrum corpuscles: Colostrum corpuscles are globules of from four to five times the diameter of the fat globules. They consist of proto-plasma which encloses fat globules. Occasionally an eccentric nucleus may be observed (see cut, page 16).



Pus: Pus corpuscles in milk appear as pale globular bodies of varying size. They possess a slightly granulated surface, which disappears on addition of acetic acid, while the corpuscles get considerably enlarged.



Pus corpuscles and epithelial cells.

Epithelial cells are found in milk but rarely, and then, perhaps, accidentally.

Lower organisms: The presence of *fungi* in milk can be detected with the naked eye only when they are grouped together in one place in dense masses. They have received considerable attention of late. It is, therefore, indicated to determine whether, in the dairy industry, they are of equal importance as we know them to be in other industries. The development of fungi is generally a very complicated process, embracing a cyclus of the most heterogeneous shapes. Moreover, these various forms depend for their

development on the nature of the substance upon which they grow. The air contains, normally, fungi; but it contains far more in damp and badly-ventilated stables. It is, therefore, but natural that milk should contain them also, since the air cannot be excluded. When milk, on standing, sours or decomposes, we find, therefore, always fungi, whether the process is a normal or an abnormal one. It is not absolutely, but at least reasonably certain, that these changes are produced by fermentation, from the fact that Appert's milk-preserving process is successfully applied in dairies.

The following species of fungi have been found in milk which is undergoing decomposition:

1. *Oidium lactis*, now known as *mycoderma lactis*, milk yeast.
2. *Mucor racemosus Fres.*
3. *Penicillium glaucum Link.*
4. *Dictyostelium mucoroides Bref.*

With these we always find bacteria and various species of vibrio, zooglœa and monades.

Specfic Gravity.

Definition: Specific gravity is the figure which indicates the relation of the weight of a body, as compared with the weight of an equal volume of distilled water at the same temperature. The specific gravity of milk, determined at 15° C., depends upon its composition, and varies between certain limits. Albuminates, milk sugar, and salts increase its specific gravity, fat diminishes it.

The difference in the specific gravity of milk, just after milking, or after standing for some time, or boiling, is, perhaps, due to the air which dissolves in the milk during the milking, when it is thus in thin layers exposed and thoroughly mixed into it.

The butter globules may be liquid or solid, according to their temperature and composition, and the specific gravity of milk may by this be influenced; but how and to what extent this is done, has not yet been investigated.

Apparatus for the determination of the specific gravity: The specific gravity of milk is determined—

1. For scientific purposes, by weighing the milk in a flask of known contents (pycnometer).

2. For practical purposes, by the use of an areometer (lactodensimeter).

Weighing in a flask: The flask used for the determination of the specific gravity is of thin glass, and is closed with a carefully ground, solid glass stopper, or one consisting of a thermometer. The latter are, for convenience sake, to be preferred. This flask should hold from 30 c.c. to 50 c.e., and the edge of its neck should not be laid outward and rounded, but cut off straight. To clean these flasks after use, they should be rinsed with caustic soda solution, then with water and absolute alcohol, and finally with ether. Cloth should be used, instead of paper, to dry and clean them externally.

It must be avoided to touch the flask with the hands while it is used, to prevent changes to temperature, which, by the consequent expansion of the fluid, would lead to inaccurate results. The temperature of fluids, the specific gravity of which is thus to be determined, should not vary more than 2° from the temperature of the air in the balance-room. Should it be warmer, it would happen, especially in the case of milk, that the fluid at the sides becomes colder and commences to contract, while in the interior, around the mercury bulb of the thermometer, the fluid retains its original temperature. It is necessary, therefore, to determine the temperature of the room by another thermometer. The temperature exerts a considerable influence upon the results. Therefore, to obtain exact readings, the bulb of the thermometer should remain in the fluid for at least one or two minutes, and then be read to 0.1 degree. The specific gravity found is corrected by the use of Kopp's tables.

VOLUMINA AND SPECIFIC GRAVITY OF WATER, ACCORDING TO H. KOPP.

TEMPERATURE. *Centigrade.*	*Fahrenheit.*	*Volume of the Water* at 0° C. = 1.	*Spec. Gr. of the Water* at 0° C. = 1.
0.	32.0	1.00000	1.000000
1.	33.8	0.99995	1.000053
2.	35.6	0.99991	1.000092
3.	37.4	0.99989	1.000115
4.	39.2	0.99988	1.000123
5.	41.0	0.99988	1.000117
6.	42.8	0.99990	1.000097

TABLE CONTINUED.

TEMPERATURE. *Centigrade.*	*Fahrenheit.*	*Volume of the Water* at 0° C. — 1.	*Spec. Gr. of the Water* at 0° C. — 1.
7.	44.6	0.99994	1.000062
8.	46.4	0.99999	1.000014
9.	48.2	1.00005	0.999952
10.	50.0	1.00012	0.999876
11.	51.8	1.00021	0.999785
12.	53.6	1.00031	0.999686
13.	55.4	1.00045	0.999572
14.	57.2	1.00056	0.999445
15.	59.0	1.00070	0.999306
16.	60.8	1.00085	0.999155
17.	62.6	1.00101	0.998989
18.	64.4	1.00118	0.998817
19.	66.2	1.00137	0.998631
20.	68.0	1.00157	0.998435
21.	69.8	1.00178	0.998228
22.	71.6	1.00200	0.998010
23.	73.4	1.00223	0.997780
24.	75.2	1.00247	0.997541
25.	77.0	1.00271	9.997293
26.	78.8	1.00295	0.997035
27.	80.6	1.00319	0.996767
28.	82.4	1.00347	0.996489
29.	84.2	1.00376	0.996202
30.	86.0	1.00406	0.995908

Determination: The flask, after having been thoroughly cleaned, is dried at 100° C., and left to cool in the desiccator. It is then weighed, and after that filled with water which has previously been freed from air by boiling, and been left to cool in a covered flask. Care must be taken that no air bubbles adhere to the glass. The stopper is then adjusted, and the outside carefully dried. It is then re-weighed, and the temperature observed. The contents of the flask, at a certain temperature, are thus determined.

After removing the water and drying, the bottle is filled with the milk, which has first been well mixed, using throughout the same precautions. If the temperature of water and milk are not

the same, the observed weights must be corrected by the above table in the following manner:

Found, weight of empty bottle.....	15.235
" " bottle + water at 18° C.....	46.327
Weight of water at 18° C.....	31.092
Weight of bottle + milk at 16° C.....	47.226
" " " empty.....	15.235
Weight of milk at 16° C.....	31.991

The water having been weighed at 18° C., we have to determine the quantity of water required to fill the flask at 16° C. The respective specific gravities of water are:

At 18° C., 0.998817; at 16° C., 0.999155.

The weight of the water required to fill the flask at 16° C. is, therefore,

$$0.998817 : 31.092 = 0.999155 : X$$

$$X = 31.102 \text{ grs.}$$

The specific gravity of the milk is, therefore, $\frac{31.991}{31.102} = 1.028$.

This is the specific gravity of the milk at 16° C., compared with water at 16° C.

Since the coefficients of expansion of milk and water differ certainly not considerably, we can also consider the specific gravity of this milk to be = 1.028 at 15° C., if compared with water of this temperature.

If once the contents of the flask are known, it is unnecessary to repeat the weighing with water for each determination. It is only necessary, from time to time, to examine the weight of the flask, to ascertain whether it has not lost in weight by the removal of small splinters of glass or by scratches.

Lactodensimeter: For ordinary determinations an areometer or lactodensimeter may be employed to ascertain the specific gravity. Quevenne's lactodensimeter is the most exact, and the one most generally used. For description and use of this instrument, we refer to the chapter treating on "Milk inspection."

Chemical Analysis of Milk.

GENERAL RULES.

For the examination of milk one must be enabled to commence the examination at once, and to carry it through without loss of time. It is, therefore, absolutely necessary that the laboratory be well supplied with all the apparatus mentioned at the end of this book, in such quantity that no time is lost by preparations of any kind.

The first process taken in hand consists in the coagulation of the milk. When this is in progress the determination of the solids and salts is commenced. After the filtration from the coagulated albuminates is finished, and while the milk is drying on the water bath, the physical properties and the reaction of the milk are determined.

Milk should be thoroughly mixed before samples for the various determinations are removed. For exact analyses it is also necessary not only to measure the milk, but to verify and correct the figures obtained by measurement by actual weighing in a covered vessel.

A careful and exact record of all data concerning the analysis is indispensable. Measures should be given in cubic centimeters and weights in grammes; and for the measurement of the temperature, the Celsius or Centigrade thermometer should be employed.

In case that the temperature has been observed on a Fahrenheit thermometer, the corresponding degrees of the Celsius thermometer may be found by the table given on page 18. For higher temperatures than those given in this table, the corresponding temperature on the Centigrade thermometer may be found by deducting 32 from the degrees read, dividing the rest by 9, and multiplying by 5. For instance:

$$185^\circ\ \text{F} = \frac{(185-32) \times 5}{9} = 85^\circ\ \text{C.}$$

and, *vice versa*, we may convert Celsius degrees into degrees Fahrenheit by the following equation:

$$85^\circ\ \text{C.} = \frac{85 \times 9}{5} + 32 = 185^\circ\ \text{F.}$$

Reaction of Milk.

While former investigators assign to milk always either an acid, alkaline or neutral reaction, later investigations have proved its reaction to be amphotere. Soxhlet states that a milk of only acid or alkaline reaction is an impossibility, since basic, neutral or acid phosphates never show a neutral reaction. To add to milk alkali until no acid reaction can be observed, would produce a milk of strongly alkaline reaction. The opposite takes place when, with the aid of acids, we desire to extinguish the alkaline reaction.

This amphotere reaction can, however, only be proved by the use of specially prepared litmus paper (see Fresenius, *Qual. Analysis*), or better yet, with Liebreich's litmus plaster plates (*Berl. Ber.*, 1, 48).

To test for the reaction, one drop of milk is brought by means of a glass rod upon the test paper (blue or red). If the red is turned blue, we have an alkaline reaction, or if the blue be turned red, an acid reaction. No change on either would prove a neutral reaction.

The reaction most generally observed and reported is the neutral reaction.

Determination of Water and Solids.

The solids are determined as follows:

10 c.c. milk are carefully weighed in a dry, counterpoised and covered platinum dish. To this absolute alcohol sufficient for coagulation is added. The coagulated mass is then dried on a water bath; and, before it has lost all its moisture, it is, by means of a spatule, carefully spread over the sides of the dish to increase its surface, whereby drying is greatly facilitated. It is then brought into an air bath, and dried to constant weight at from 100 to 110° C. To this end the weighings are repeated every hour, the dish, with cover, being allowed to cool in a desiccator before each weighing. We thus have:

Platinum dish + cover + dry solids,
Minus platinum dish + cover,

Leaves dry solids.

Difference between milk taken and dry solids = water + volatile substances.

Good milk should have 12.5 per cent. of solids.

Determination of ashes and phosphoric acid: The residue from the determination of solids is then heated first over a small flame, and finally at a dull-red heat, until complete incineration is effected. It is advisable to incinerate, if possible, in a muffle. The dish is then covered, and allowed to cool in the desiccator, and finally weighed.

Platinum dish + cover + ashes,
Less platinum dish + cover,

Leaves ashes.

The ashes of milk vary from 0.5 to 0.75 per cent. More than 0.75 per cent. found in an analysis would indicate the addition of alkalies, which are frequently used during the hot season in the larger cities to retard souring. The reaction of such ashes is then alkaline, and will show effervescence on the addition of acid. The ashes of normal milk show a neutral reaction, and do not effervesce with acids.

The phosphoric acid is easily and accurately determined by the following method: In the manner stated above, 50 c.c. milk are dried and incinerated. The salts are then dissolved with some hydrochloric acid, and the solution is brought to 20 c.c. To 10 c.c. of the *cold* solution, ammonia or caustic soda is added until the reaction of the fluid has become alkaline. This is then acidified with acetic acid. The solution thus treated contains but little acetates, which would interfere with the delicacy of the end reaction of ferrocyanide of potassium and uranium. To this solution a standardized solution of uranium is added. When the precipitate ceases to increase, the whole is boiled for a few minutes, and one drop of the clear supernatant liquid is brought on a porcelain plate, and tested with a solution of ferrocyanide of potassium. A brown coloration indicates the presence of an excess of uranium solution, which, however, may disappear again on continued boiling. The addition of uranium solution is continued until the reaction remains. It is of advantage to make two titrations at a time, using in one 0.5 c.c., between the tests, and in the other, 0.1 c.c.

The uranium solution is made of such strength that 1 c.c. = 0.005 gr. phosphoric anhydride. As regards the composition of milk ashes, we refer to page 8.

For a complete analysis of the ashes, not less than 500 c.c. of milk should be taken. For the method of analysis to be pursued, we refer to Fresenius, *Quantitative Analysis.*

Coagulation and Determination of Albuminates and Fats.

In the method until now commonly used, the coagulation was effected by acetic acid or carbonic anhydride. This method originates with Hoppe-Seyler, but gives inaccurate results, as has been proved by the investigations of Liebermann, Manetti, Musso, v. Nencki, and the author (see Kritik der Verschiedenen Methoden zur Bestimmung der Albuminate und Fette, *Fresenius' Zeitschrift*, 1880, and Petersen's *Forschungen*, 1879, 7, 301.

A very reliable and quick method is Ritthausen's, who proposes to effect the precipitation of the albuminates and fats by means of sulphate of copper solution. From a neutral or slightly acid solution, the coagulation is easily effected in the cold. The accuracy of the method has been verified by a long series of examinations of milk in which it has been employed.

Ritthausen proposes to dissolve 63.5 grs. pure sulphate of copper in crystals to 1 liter. 10 c.c. of this solution contain 0.2 gr. CuO. A second solution contains 50 grs. caustic potash in 1 liter of water. Its specific gravity is 1.048. Author uses the same solutions, but has modified Ritthausen's method by using a smaller quantity of sulphate of copper.

The coagulation is carried out as follows: 10 c.c. milk are weighed in a beaker covered with a watch-glass, and then diluted with 100 c.c. water. After mixing well, the solution of sulphate of copper is gradually added until the precipitate settles well, while the liquid becomes perfectly clear. For this 2.5 to 3 c.c. of copper solution are required, while Ritthausen uses 5 c.c.

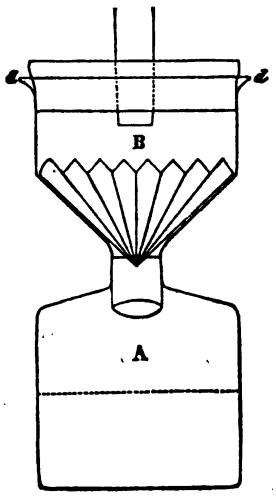
Then potash solution is added to decompose the excessive quantity of cupric sulphate. For this, one-half the volume of the copper solution is required. The coagulated albumen enclosing

the fat globules settles quickly, leaving the fluid perfectly clear. The fluid is decanted through a filter which had previously been dried at 110° C., and weighed between two watch-glasses. The precipitate is then stirred up with 100 c.c. of water. After allowing to settle, the water is likewise decanted through the filter, and finally the precipitate is brought upon it. The beaker is then cleaned by means of a rubber washer, and washed with water until everything is transferred to the filter. Thus, about 240 c.c. of filtrate are obtained, which are diluted to make it exactly 250 c.c. This filtrate is used for the determination of milk sugar.

The beaker contains always some fat, which must be added to the fat obtained from the albumen precipitate, and is, therefore, set aside until this operation is in order. The copper casein precipitate, containing all the albuminates and the fat of the milk, excepting that portion which was left on the beaker, is then, by means of a small spatule, well distributed over the whole surface of the filter, which had been previously transferred to a large watch-glass. This aids the evaporation of the water considerably, and becomes necessary from the fact that the application of higher temperatures must be avoided. To effect drying, the filter may be exposed to the sun, or the watch-glass may be placed where it is exposed to a moderate temperature. From time to time the precipitate is again worked with the spatule, care being taken that the filter is not injured. After some time the residue becomes a finely divided dry powder, which can easily be collected in the point of the filter, and from which the fat can be extracted.

Determination of fat: The ordinary open extraction of the fat, consisting in the washing of the precipitate with warm ether on an open funnel, until the precipitate is exhausted, has disadvantages, resulting not only in a loss of fat by effervescence, but also in the waste of a considerable quantity of ether. Far more economical is the use of a closed apparatus for the extraction of fat.

The apparatus constructed for this purpose by the author is arranged as follows:



A is a flask of from 5 to 6 centimeters in width and 6 to 7 centimeters in height. On this stands the funnel *B*, the neck of the funnel being carefully adjusted into the neck of the flask by grinding. The funnel is from 6 to 8 centimeters wide and from 8 to 10 centimeters high. The upper edges, *d d*, of the funnel are bent outward to allow of an easy adjustment of the cork, and the lower aperture must remain of full width, and should not be narrowed down, as is often done.* The filter containing the precipitate is then loosely inserted into the funnel, which then is adjusted to the previously weighed flask. The filter is now washed with some absolute alcohol to remove the last traces of moisture from the precipitate. The beaker, which had been used for the coagulation, and which had been set aside, is now freed from fat by repeatedly washing it with small quantities of ether, which are poured upon the filter. This is continued until the flask is filled to about one-half with ether.

The apparatus is then, by means of a good cork, free from pores,† connected with an inverted Liebig's cooler, and put upon a

* An ordinary wide-necked flask, to which the funnel is attached by means of a good cork, may serve in the place of the complete apparatus, as described.

† Corks may be prepared by covering the outer surface with silicate of soda.

sand bath, which is cautiously heated by means of a Bunsen burner. The heat must be so regulated that the filter swims continually to one-half its height in condensed ether, and the cooling must be sufficient to prevent the escape of ether. Thus the complete extraction of the fat may be effected in about one hour. The funnel is then removed, and the flask is connected with a cooler, and the ether, which contains alcohol, recovered by distillation at very low temperature. The flask is then put in an air bath, laying it on its side, and dried for one or two hours at a temperature of 100 to 105° C. After cooling in a desiccator, it is weighed.

The increase of weight corresponds to the amount of fat contained in the quantity of milk taken for analysis. The residue in the filter is then dried for two hours at from 110 to 120° C., and weighed between two watch-glasses. After this it is transferred to a porcelain or platinum crucible, and incinerated.

Weight of filter + dry coagulum,
Minus weight of filter + ashes,

Leaves albuminous substance.

The nitrogen determination in this substance, if required, must be made by Dumas' method, on account of the presence of cupric oxide, which, in an attempt to use Will Varrentrape's method, would cause a loss by the partial destruction of the ammonia. The determination of albuminates by simple incineration, is, however, sufficiently exact.

For a description of Dumas' method for the determination of nitrogen, we refer to Fresenius, *Quantitative Analysis.*

A separation of so-called albumen and casein is wrong; a determination of the sum of all albuminous substances is, generally, all that is required, if the investigation is not to go into such details as those mentioned on pages 6 and 7.

Determination of Milk Sugar.

The sugar of milk is determined in the 250 c.c. fluid which have been filtered from the coagulum obtained by the addition of cupric sulphate to milk. The method adopted by the author consists in the titration by means of Fehling's solution.

It is well here to mention that sugar of milk is the only sugar which can accurately be determined by the use of this method, provided the original plan of manipulation is adhered to.

The author proposes to prepare two separate solutions to avoid the changes which Fehling's solution always undergoes. To this end he prepares a standard copper solution, containing in 1 liter at 15° C. 34.64 cupric sulphate, purified by repeated crystallizations, grinding, and drying between filter papers. The second solution is prepared by dissolving 173 grs. of rochelle salts in 350 c.c. of water, and boiling. After cooling, 600 c.c. of sodium hydrate solution (sodium hydrate purified by crystallization from alcohol) of 1.12 specific gravity, which had likewise been heated to boiling, are added. The mixture is finally brought to 1 liter at 15° C.

These two solutions are kept separate in a number of small well-corked bottles, and are only mixed when used.

For the titration of the sugar, the following plan has been adopted : 5 c.c. of each of these solutions are brought into a porcelain dish, with 20 c.c. of water, and heated to boiling. The sugar solution is then gradually added from a burette, care being taken that the solution is kept boiling constantly.

Evaporated water should, from time to time, be replaced by the addition of distilled water. The formation of dry crusts on any part of the dish must be prevented. They are likely to get overheated, and thus may give rise to the formation of products which also reduce copper solution. The titration should be repeated at least once, and must be completed within five to ten minutes. The process is at an end when all the copper is thrown down as red cuprous oxide, which is best determined by the complete disappearance of the blue color in the liquid. To observe this better, the dish is slightly inclined, so as to enable one to examine the color against a white background. In doubtful cases, a trace of the fluid is filtered through a very small filter, acidified and tested with potassium ferrocyanide. A red color indicates the presence of copper, and a few more drops of the sugar solution are added, the boiling being continued until the precipitation of the copper has been completed. Care should also be exercised that no sugar remains in the fluid. If, therefore, no copper reaction ensues, we must always test for sugar in a separate portion by the addition of copper solution, and boiling.

It is to be observed yet, that the decolorized solution, on standing over the cuprous oxide, absorbs oxygen from the air, and becomes again blue. For this reason each tritration must be carried to an end in the shortest time, and a subsequent coloration is not to be taken into account. We, therefore, determine the exact quantity by two to three titrations. The first titration is only used to determine the reducing qualities roughly.

1 c.c. Fehling's solution = 0.00676 grs. milk sugar.

It is not advisable, as some propose, to take a drop of the fluid out by means of a glass rod, and to test this on a porcelain plate for copper, as described above. Finely divided cuprous oxide remains frequently for a long time suspended in the fluid, and the least trace of it in the fluid is apt to deceive.

The calculation is as follows:

Provided we used 18.2 c.c. of the sugar solution to reduce 5 c.c. copper solution, we have:

$$18.2 : 250 = 0.0338 : X$$
$$X = 0.464 \text{ milk sugar.}$$

Occasionally the sugar of milk is determined by difference.

According to the *method of Soxhlet*, 25 c.c. milk are diluted with 400 c.c. water, and coagulated by means of a solution of sulphate of copper; the precipitate is filtered off, and the fluid is brought to 500 c.c.

100 c.c. of this solution are then transferred to a beaker, and, after adding 50 c.c. of Fehling's solution, are boiled over double wire netting, while the glass is kept covered to prevent loss. After six minutes' boiling, the sub-oxide of copper is collected on an asbestos filter, dried, and reduced by heating in a current of hydrogen gas. The method is said to give quick (?) and accurate results. According to Soxhlet's investigations,

mgrs. of copper weighed correspond to mgrs. milk sugar:

393.7	300
363.6	275
333.0	250
300.8	225
269.6	200
237.5	175
204.0	150
171.4	125
138.3	100

ABNORMAL COWS' MILK.

Abnormal cows' milk is not merely an adulterated milk, but all milk which is not fit to be used as food without detriment to the interest of the consumer.

Colostrum Milk.

The colostrum is the first nourishment for the young animal, and, as such, of considerable importance; but it is not suited for dairy use. All dairy societies, for this reason, prohibit its sale. Condensed milk factories refuse the milk until the sixth day after calving, while in cheeseries they accept it only on the eighth day, since colostrum is said to interfere with the curdling and the subsequent process of ripening of the cheese.

Engling has made very thorough investigations regarding this milk. He says: "The first three to four liters of the beastings milked "after calving, are a yellowish-white mucilaginous fluid, which is "frequently colored by blood, exhibiting a reddish-brown tint. It "possesses a peculiar odor, and has, at 15° C., a specific gravity of "from 1.06 to 1.08.

"The cream rises very slowly; but, after long standing, where-"by a skin of dry albuminates forms on the surface, from 50 to 75 "per cent., by volume, of cream is obtained. The boundary be-"tween milk and cream is not well marked.

"Colostrum is, on heating, converted into a solid cake. It pos-"sesses originally an acid reaction, and keeps well, especially after "a dry albumen skin has formed on its surface. It then appears un-"changed, even after two weeks' standing. The casein, on curd-"ling, developes a gas, and between the heavy flocks remains a red-"dish-colored, opalescent serum, which bears great similarity to "blood serum. The products obtained after this first milking as-"sume gradually the character of cows' milk, until, after four days, "the secretion of the glands shows all the properties of normal "milk."

The change from colostrum to milk which may be used for industrial purposes, is, therefore, effected in a comparatively short

time. It is slower with younger animals and such which are of inferior development, as far as production of milk is concerned.

Good milking cows will generally on the third or fourth day after calving, produce milk which can be boiled without showing any coagulation of albuminous matter; while young animals will furnish, even on the sixth and seventh day, a milk which will show partial coagulation on boiling, and in which colostrum corpuscles can be found with the aid of the microscope.

Beside blood, albumen, casein, fat, and ashes, we find the following substances as normal constituents of colostrum: sugar, globuline, nucleine, urea, lecithine, and cholesterine. The presence of milk sugar has, as yet, not with certainty been demonstrated. Eugling found the colostrum of twenty-two cows, of the ages from three to thirteen years, composed as follows:

Specific gravity	1.058	1.079
Ashes	1.180	2.310
Fat	1.880	4.680
Albuminates	11.180	20.210
Casein	2.650	7.140
Sugar	1.340	2.830

Colostrum milk is especially characterized by comparatively large (0.005 to 0.025 m.m. diameter) granulated corpuscles. Aside of these, fragments in various degrees of dissolution are found, which frequently consist only of conglomerates of fat globules. Bunches of cells from the lactiferous ducts, generally larger than the colostrum corpuscles, are also occasionally met with (see fig., page 16).

Poisoned Milk.

Metallic poisons: Milk may occasionally contain poisonous metallic substances. These are derived either from sour food kept in metallic vessels and consumed by the cow, or may be imparted to souring milk which is kept in metallic vessels. (Taylor, *On Poisons*, p. 412.) The acids which are formed during souring dissolve the oxides of copper, lead and zinc easily. It is said that zinc vessels are used in some localities to delay the souring.

Examinations for Metallic Poisons: If the presence of large quantities of metallic substances is suspected, the examination may be carried on in the following manner:

From 50 to 100 c.c. of milk are precipitated with a few drops of muriatic acid. After heating to boiling, the solution is filtered from the precipitate, and the latter washed. The solution is then evaporated to about 25 c.c., and again filtered to remove some albumen and fat, which have become insoluble during the concentration of the liquid. The concentration of the fluid is then continued until about 10 c.c. remain. These are distributed into three test tubes, one being used for the determination of the presence of zinc, another for copper, and the last for lead.

The presence of *zinc* is determined by means of sulphuretted hydrogen passed through the almost neutralized solution. A white precipitate would indicate the presence of zinc. Frequently sulphur is precipitated, which, however, on heating on platinum foil, burns without leaving a residue. The precipitate is therefore to be more closely examined. The hydrochloric solution is made alkaline with ammonia, and sulphide of ammonia added, when a white flocculent precipitate will be formed in the presence of zinc. In case that only small quantities of zinc are present, white turbidity ensues, and the precipitate becomes flocculent only after long standing.

Lead is found in the hydrochloric solution by passing sulphuretted hydrogen through it, which produces a grayish-black precipitate. Chromate of potassium produces a yellow precipitate of chromate of lead.

In the presence of *copper*, ammonia produces a dirty gray color; potassium ferrocyanide a brownish-red color, or precipitate. If some of the solution be brought on a clean piece of platinum foil, and a clean knife be laid upon it, the latter becomes, in the course of several hours, coated with a layer of red metallic copper

If these metals are present in only minute quantities, it is better to destroy the albuminous matter by means of hydrochloric acid and chlorate of potassium. The rest of the operation remains the same.

Vegetable poisons: A case is on record wherein, in the City of Rome, twenty-one persons were poisoned, in the year 1875, by the milk of goats which had fed upon momordica, the fruits of which are known to possess highly purgative properties. The patients recovered under medical treatment.

Milk Containing Medicines.

Lewald's experiments have proved that medicinal substances are rapidly conveyed by the milk; so, for instance, lead, arsenic, oxide of zinc, sub-nitrate of bismuth, tincture of iodine and iron, antimony, and mercury salts.

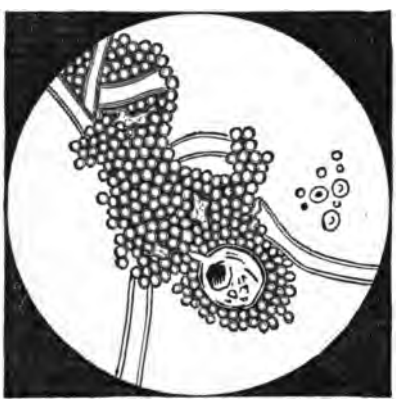
It has not been determined that milk suffers, under the influence of these substances, also a quantitative change; but the experience of physicians has demonstrated that medicines administered to the mother act, through the medium of milk, upon the suckling.

Milk as the Cause of Disease.

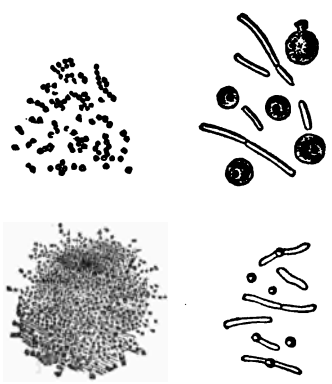
It is a well-known fact that the use of milk, especially during the hot season, when it undergoes changes quite rapidly, is attended with some risk. Only later investigations have proved that milk may also cause specific diseases. Milk has, in many cases, proved to be the bearer of disease germs, and thus has caused the transmission of contagious and infectious diseases.

Without reference to special cases, we will, to avoid prolixity, only describe the diseases and their causes.

The milk may be the cause of infection:



Milk containing algæ, obtained from a cow which drank stagnant water. According to Low.



Bacteria.

1. By direct communication of the infection, derived mainly from impure water, used either for watering cattle or as adulter-

ant of milk, or for cleansing the vessels used for keeping the milk. John Oyle observed that cattle using stagnant water during summer, became feverish. The microscopic examination of blood and milk proved, in both, the presence of large numbers of microscopical organisms, the same as were found in the water. The milk was unfit for use, and normal milk mixed with a few drops of the same water would undergo the same changes.

So may bacteria or spirilla, by reason of the use of impure water, or other means, enter the milk, where they produce putrid fermentation, which only in its latter stages is easily recognized by odor and taste. These smallest organisms, variously magnified, are represented in the cut given on page 33.

2. By absorption of the infectious material from the air of the stable and dairy, or by contact with sick persons.

3. By abnormalities pre-existing in the milk, from the fact that it is derived from sick animals.

Considering that a contagion finds in milk not only the conditions for its preservation, but also for its propagation, we must admit the possibility that, by the use of infected water for rinsing milk vessels, the small quantity of water adhering to the sides of the vessel may well suffice as a cause of disease. The same is true for infection by air.

In England, many epidemics occurred which have been traced to the milk as cause; and, amongst these, impure water, employed in the manner described, seems, in most cases, to have been the originator.

Robinson mentions one case where milk, which was stored in the sick-room of a typhus patient, caused an epidemic of ***typhus.***

Bell relates an epidemic of ***scarlatina,*** which was caused amongst the customers of a certain dealer whose cows had been milked by scarlet fever convalescents.

A similar case is mentioned by Taylor.

Gerlach was the first who called attention to the dangers to which consumers of milk are exposed, which is derived from cows sick with ***tuberculosis.*** This chronic disease attacks mainly stable-fed animals, which transmit this disease to hogs, sheep, calves and rabbits fed upon their milk.

Stang mentions the case of a child which died with all symptoms of tuberculosis, and which had been infected by the use of

the milk of a tuberculous cow. Experiments of Klebs have proved that the contagion is not destroyed by the ordinary boiling of the milk. Ballinger has lately corroborated these observations.

The milk of tuberculous animals is said to be thicker than ordinary milk. The reaction is alkaline. The cream rises quickly. Cream and milk are apt to putrefy in a short time. The milk is not easily curdled by rennet or by heating.

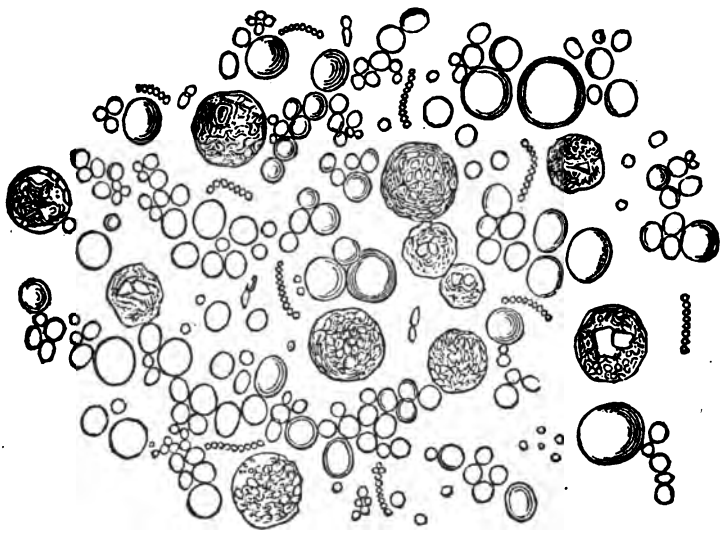
Anthrax: Milk of cows sick with *anthrax* is said to become stringy, and in this state it breaks easily. Infected milk should not be used. It is said that cattle are predisposed to this disease when fed on distillery swill or the refuse of starch and beet-sugar factories.

Aphtha epizootica: Anaker says: "In some cases of *aphtha* "*epizootica* (hoof and mouth disease), especially when the mucous "membranes of the lacteal ducts are affected, or when the contents "of the bladder find their way into the milk during the milking, "the milk appears thicker, phlegmy, more yellow, lumpy, and "blood-streaked. It emits a putrid odor, and possesses a repug- "nant taste. Such milk will part, on standing, into a yellow se- "rum, and a sediment which contains pus corpuscles and finely "granulated masses in a state of dissolution. Such admixtures "increase the specific gravity of such milk, while the percentage "of fat, casein, and sugar are diminished.

"The amount of salts is increased. The reaction of the milk "is acid when the disease is at its height. It, therefore, curdles "easy when heated to boiling. The cream yields often no butter; "but butter made from such milk shows an unnatural yellow color. "Whether such milk will prove injurious to the health of con- "sumers, depends upon the nature of the abnormal constituents.

"Boiling does not always remedy the injurious properties of "such milk. The use of such milk has been the cause of the fol- "lowing symptoms: fever, blisters on the mouth and feet and the

" hands, of the milkers, headache, and rheumatic pains affecting " the whole body."



Milk of cows sick with the mouth and hoof disease. Acccording to G. T. Brown. Aside of the easily recognized butter globules, it contains large, dark, and granulated cells, vibrios connected to strings, and small elliptic bodies, of which always two are connected and show motion (*bacteria*).

The infection through milk is considered to be partially caused by small blisters on the teats, the exudation of which becomes admixed to the milk.

C. Monin examined the milk of a cow sick with ***cattle plague,*** and found its composition very variable:

Water and volatile	81.22	to	86.53
Salts	1.18	"	1.54
Albuminates	9.07	"	11.19
Fat	1.77	"	3.75
Sugar of milk	0.46	"	1.85
Specific gravity	1.002	"	1.057

The milk in this affection is very rich in albuminates and salts, but poor in fat and milk sugar.

Influence of Food, etc.

The influence of food upon the milk of animals is a subject of some importance, and should engage the attention of physicians, since many waste products of important manufactures are at present utilized for feeding purposes, either alone or in combination with other food.

By means of such foods, substances may enter into the composition of milk, which make it totally unfit to serve as nourishment for infants.

Much has been written and said to defend the use of such waste products as food, yet nobody prefers such milk to milk from cows which have been normally fed on good pasture.

Being constantly housed can, likewise, not be of advantage to the well-being of an animal, especially if the stables are damp and badly ventilated.

Potato distillery swill: Only a few fragmentary investigations have been made to determine the influence which is exerted on the quality of the milk of cows which are fed on potato distillery swill. That the milk of such cows cannot be good may be presumed, if we consider that the swill is not always fresh, nor free from alcohol.

Ried found that such milk did not contain alcohol, but that it is very poor in fat (1 to 1½ per cent.) The swill is poor in carbohydrates, since the conversion of the starch into sugar, and finally alcohol, is the object of the treatment.

Albuminates, acids and salts predominate; hence, such milk is richer in casein and salts, and comparatively poor in sugar and fat.

Clark found that the fat globules of such milk are small and few, and that they are disposed to adhere together, forming aggregates of considerable size. In two specimens, uncommon numbers of epithelial cells were observed, some of which showed a peculiar granulation, while others were colored. Some of these were very small and enclosed butter globules, thus showing that they had formed the coating of the lacteal ducts, and that they had loosened before their inner structure had been completed. The deleterious influence on the health of consumers, especially that of children, which is caused by such milk, has been traced to the circumstance

that such milk does not easily coagulate, and that the butter globules are frequently united to large masses. Retarded coagulation prevents easy digestion, and causes through an overloading of the stomach, symptoms of irritation. (See Petersen, *Milchzeitung*, 1877, No. 21, Ueber die schaedlichen Folgen der Branntweinschlempefuetterung fuer das Vieh.)

Brewers' grains: The investigations regarding the influence upon the milk of cows fed with brewers' grains are not conclusive; yet we know that such milk is inferior, unless the grains are fed quite fresh.

Milk in fermentation: E. Reichardt mentions a case of rapid *fermentation of milk* in a village in the neighborhood of Jena, Germany. He looked upon the high temperature of the store-room as the main cause for this rapid fermentation. Everything that may induce fermentation should be excluded from the dairies as well as stables. Fermentation might also be caused by feeding cows on fermenting brewers' and distillers' grains and wash. ***Pus*** has occasionally been found in milk; it is derived from ulcers in the interior of the udder. Other diseased conditions of the lacteal glands may cause the presence of ***mucus*** in milk.

The facts related in the foregoing chapter are of great importance, since they justify the so much needed sanitary inspection of the milk as it reaches the markets, especially in larger cities; but such supervision should be extended to include the animals themselves, their food, water and housing.

Observations as to sickness amongst cows, inferior drinking water for the cows, and untidy handling of the milk, may frequently help to explain cases of sickness, especially amongst children.

Adulteration of Cows' Milk.

The adulteration of milk—in our climate, cows' milk—is in larger cities an every day occurrence. The consequences of this practice are the more to be deplored, as they mainly befall the infants, who often depend upon milk as their sole nourishment. In consequence of this, many children are committed to a sickly and languishing existence, while many perish. It is for this reason that city governments experienced the necessity to prevent these practices, by an inspection of the article as it reaches the market.

The adulterations are as follows:

1. Addition of water.

2. Partial removal of cream, skimming.

3. Skimming and watering.

4. Mixing of partially skimmed (evening or morning) milk with whole milk.

5. Foreign substances to disguise the altered or unnatural appearance of milk.

Most cases of adulteration are to be classed under 1 to 4, those under 5 being used to reestablish a normal appearance of adulterated milk.

The following substances are known to be used for this purpose: sugar, gum arabic, starch, dextrine, egg albumen, yolk of eggs, earthy substances, alkalies and dyes, to blend the blue color of skim milk.

Most of these adulterants exist more in books than that they are actually met with, for substances which can easily be found by simple chemical reactions, or even by mechanical means, or which may easily be discovered by taste or smell, are not those which fraudulent dealers would be apt to choose.

Those who adulterate know well that chemists possess all the means to detect such coarse adulteration; they therefore confine their operations mainly to watering, and the mixing of skim milk with whole milk, in various proportions.

Watery milk: Watery milk of a bluish-white color, poor in fats and solids, is generally derived from cows under inferior treatment, or when fed with extraordinarily poor and watery food. A measure for the value of such milk is its specific gravity. This is, however, governed by the quantities in which the various constituents are present, for while salts, albuminates and milk sugar tend to increase the specific gravity, the fat tends to diminish it.

If whole milk be mixed with water, the specific gravity will be reduced, and analysis will show an excess of water and, correspondingly, a diminished quantity of solids.

If milk be more or less skimmed, the specific gravity is increased. By means of the lactometer or lactodensimeter, dealers are enabled to dilute it with water to such an extent, that the specific gravity reached is within the limits of the law. A determina-

tion of the fat will show whether this has been practised, as it will also in the case of mixtures of skim milk and whole milk.

To determine whether an abnormally watery milk or a watered milk is before us, we may use chemical or mechanical means. For scientific investigations only the former are used, and must consist in a complete quantitative analysis. For practical purposes, we can confine ourselves to a determination of fat and total solids.

Physical examination: The physical examination of milk consists mainly in the determination of the specific gravity. The microscopical examination is not fit for quantitative results, but can merely be used for the determination of abnormalities, as blood, pus, and colostrum corpuscles, or solid adulterants. It cannot be used to determine with certainty the adulteration with water, though it is a fact, that watered milk contains the larger and smaller fat globules in the same proportion as whole milk, though further separated from one another. The want, or deficiency, of the larger or medium size globules, would indicate skimming.

Conrad has shown how difficult it is to obtain a good sample on a slide, representing really an average of the milk to be examined; the same milk well mixed furnishing, by all the care that can be bestowed, samples which show differences as regards the number, size and distribution of the fat globules.

The estimation of the number of fat globules in the field is also quite arbitrary.

Later on, in the chapter entitled "Milk inspection," a method for the determination of the fat will be described, which, if not absolutely accurate, admits at least of safe deductions. The ***specific gravity*** of normal market milk (such which represents the milk of several cows mixed), which possesses an average composition as follows:

Water and volatile substances	87.50
Salts	0.50
Fat	3.50
Albuminates	4.00
Sugar of milk	4.50
	100.00

ranges, ***according to many thousand examinations,*** in different countries, ***from 1.029 to 1.033.*** A milk, therefore, which contains

more than 87.5 per cent. of water, and which has a lower or higher specific gravity than 1.029 to 1.033, must be considered as inferior or adulterated; also when it contains less than 3 per cent. of fat, and when it otherwise shows considerable deviations from the figures given above.

Yet such a milk cannot be directly considered as adulterated, unless the sources of the milk have been examined, and until it has been clearly demonstrated that the milk produced by the cow does not show the same deviations from the average, as the milk offered for sale.

Sour milk: The sale of sour milk, *i. e.*, such which will curdle on heating, should be prevented.

It happens frequently, especially during the summer, that milk curdles before the examination could be commenced. Schroeder and Dietzsch have stated that a simple determination of the specific gravity of the whey is sufficient to establish an adulteration by water. The specific gravity of pure whey is 1.026, and a lower specific gravity would indicate addition of water. It would be exceedingly desirable and would greatly aid in the inspection of milk, if this statement could be verified by investigations in other localities.

The following substances are used as adulterants:

Starch and flours: Such admixtures thicken the milk; the taste and flavor of flour is easily distinguished. Such milks form, on standing, a pasty sediment. After boiling or curdling, the milk appears thready. The addition of starch is proved either by means of the microscope, or by testing the whey after filtration and concentration to one-quarter its volume, with tincture of iodine, when a blue color will ensue.

Dextrine: Milk containing dextrine has a sweetish taste; the concentrated whey with tincture of iodine, becomes light violet or the color of red wine.

Gum arabic: The presence of gum arabic is determined in milk by coagulation with acetic acid, filtering and concentrating the serum to one-fifth its volume. Absolute alcohol precipitates the gum as a white flocculent mass resembling casein (may contain albuminates). Chevalier and Lassaigne state that this precipitate presents a streaky appearance.

Coloring matters: The use of colors for the coloring of butter and cheese has become so common in dairies, that now we find them occasionally used for the coloring of poor blue milk. They may be detected in the following manner:

500 c.c. of milk are coagulated with acid, or better, by the addition of 70 per cent. alcohol.

The liquid is then filtered off and evaporated to 50 c.c. Addition of soda or ammonia produces a dark brown color in the presence of ***turmeric.***

Annato: A blue coloration on addition of concentrated sulphuric acid, would indicate the presence of annato.

Preservatives: To prevent the souring of milk during the hot season, various substances have been recommended. The application of these by producers and dealers should not be tolerated, but should be left to the consumer's choice.

Producer and dealer should attend solely to cleanliness of treatment and the cooling of the milk, which even during the summer is sufficient to allow the safe transportation of the milk for considerable distances. To prevent souring, the use of carbonate or bi-carbonate of soda or potash is tolerated in France and England.

To demonstrate their presence, 50 c.c. milk are coagulated with 70 per cent. alcohol. The fluid is filtered and evaporated to dryness. The residue, on addition of hydrochloric acid, will effervesce when these salts had been used.

Neither normal whey nor milk ashes contain alkaline carbonates.

For a qualitative and quantitative determination of the ***alkalies*** in milk, at least 500 c.c. are required. In some cases, ***milk of lime*** has been used as a means of preserving milk. The reaction of such milk is alkaline. After coagulation with acetic acid, the whey is evaporated to one-sixth of its volume, filtered, and tested with sulphuric acid, which, in the case of lime having been used, will produce a precipitate of gypsum. (*Chalk* has also been employed. Of about 300 samples examined by *Editor* for the Metropolitan Board of Health, in New York, only one sample contained chalk.)

Salicylic acid and salicylate of soda have, of late, been recommended and used for the preservation of milk. To determine its presence, 100 c.c. of milk are coagulated by the addition of 70 per cent. alcohol. The whey is filtered off, and evaporated to

one-eighth its volume. It is again filtered, and then shaken with ether. Perchloride of iron added to the ether solution, will produce a violet color if salycilic acid is present. Schulz states that a solution of salicylic acid in water, with some cupric sulphate solution, becomes a beautiful emerald green. This reaction is even more brilliant when the sodium salt is used, and can be easily recognized when dissolved in the proportion of 1 : 2000 parts of water. Alcohol hastens the appearance of the color. Acids and ammonia prevent the reaction.

Boric acid and borax being more easily soluble, more active and cheaper than salicylic acid, are used quite frequently as preservatives. To determine their presence, 50 c.c. of milk are coagulated with some acetic acid, and the filtrate evaporated in a platinum dish. The residue, after drying, is incinerated. The ashes are then heated with some alcohol containing from 1 to 2 per cent. of conc. sulphuric acid. When the alcohol is then lighted, it will burn with a flame which appears green colored at the edges, if boracic acid be present. H. Gilm proposes to use the following method, which is said to have the advantage of not only producing a greener flame, but one which appears uniformly colored. The boric ether vapors produced by the boiling of boric acid, concentrated sulphuric acid and alcohol, are passed through a narrow tube into a wider tube standing in vertical position. The mixture of air and vapors is then ignited at the upper end of the wider tube.

Quack preservatives, at very high prices, are also in use, and widely advertised. The most widely known are :

Aseptine, which is recommended for the preservation of milk and cream, and which, according to Nettl and Fleck, consists merely of finely pulverized boracic acid.

Glacialine is a mixture said to contain mainly boracic acid and borax.

MILK OF OTHER ANIMALS.

Goats' Milk.

Goats' milk is for the mountaineers what cows' milk is for the inhabitants of the flat lands, for the reason that at places where cows fail to obtain sufficient nourishment on pasture, or where this could be obtained only under great danger, the goats will yet thrive. The goat serves as the poor man's cow. The properties of goats' milk are as follows:

Appearance: Color, white to yellowish.

Consistency: Generally thicker than cows' milk.

Odor: Specific and strong, especially developed in the milk of goats which are kept in the stable.

Taste: Specific and sweetish.

Specific gravity: Varies considerably and averages from 1.028 to 1.036.

Chemical composition: It is richer than cows' milk, but variable in composition.

Specific gravity average, 1.032.

Water and volatile substances	85.0 – 87.00
Salts	0.5 – 0.75
Albuminates	4.0 – 6.00
Fat	3.5 – 5.00
Milk sugar	3.5 – 5.50

Sheeps' Milk.

Similar to the goats, the sheep are indigenous to mountainous countries. It is in such countries only that sheep are kept, mainly on account of the milk which they furnish; so for instance, in the Lozière, the Appenine and the Karpathian mountains. The many points which mountain dairies and the dairies of the marshy flat lands have in common, is also illustrated by the fact that sheep are kept for their milk in Holland (Martiny).

Appearance: Color, yellowish-white.

Consistency: It is richer than cows' or goats' milk; the cream rises slowly, and the butter made from it is soft, greasy, and does not keep well.

Odor and taste are similar to cows' milk.

Specific gravity: 1.034 to 1.042.

Chemical composition:

Water and volatile substances	80.0 – 85.00
Salts	0.5 – 1.25
Albuminates	4.0 – 6.50
Fat	4.0 – 7.00
Milk sugar	4.0 – 6.00

Asses' Milk.

Apart from the milks previously mentioned, asses' milk is oftenest used as a substitute for breast milk, especially in France. The properties are:

Appearance: Color, white.

Consistency: More water than any of the milks previously described.

Taste and odor are similar to cows' milk, but sweeter.

Specific gravity: 1.030 to 1.036.

Chemical composition:

Water and volatile substances	89.00 – 92.0
Salts	0.25 – 0.5
Albuminates	1.50 – 3.0
Fat	1.00 – 2.5
Milk sugar	4.50 – 6.0

Mares' Milk.

The keeping of mares for the purpose of utilizing their milk, is at present practised only by some half cultivated races, and in the kumyss establishments, where it is used for the manufacture of an intoxicating drink, called kumyss.

Mares' milk possesses the following properties:

Appearance and consistency: Whitish and watery, like asses' milk.

Odor and taste: Similar to asses' milk, but sweeter on account of a frequent preponderance of milk sugar.

Specific gravity: 1.031 to 1.036.

Chemical composition:

Water and volatile substances	90.00 –	92.5
Salts	0.25 –	0.5
Albuminates	1.50 –	1.0
Fat	0.50 –	1.5
Milk sugar	4.50 –	6.5

The description of other kinds of milk, apart of those already mentioned, are of little value. The examination of such milks is based upon the same principles as have been prescribed in the case of cows' milk.

CONDENSED AND PRESERVED MILKS, WITH AND WITHOUT SUGAR.

Condensed Milk with Sugar.

Condensed milk and milk preserves have until lately been prepared from cows' milk only.

Historical remarks: It is frequently, but erroneously, stated that Gail Borden was the inventor of condensed milk. This is, however, not so. The process of milk condensation is a European and not an American invention, for long before Gail Borden were condensed milks prepared by various processes known in France. So that of Adolphe Anaclet Nalbec (1826), Braconnot (1830), Grimaud (1835), J. M. de Lignac (1847). Simultaneously this subject received attention in Germany and England. Gail Borden's patent dates from the year 1856. He can, therefore, not be called the inventor of condensed milk; but to him belongs the merit of having first prepared condensed milk by a rational process and in a practicable form. In later years this process was first employed in the United States, but its use extended rapidly to other countries. Switzerland, England, Germany and many other countries, possess now establishments manufacturing this modern commodity, which, apart of cheese and butter, is at present not only the most popular milk-food, but one which finds more consumers from day to day.

The condensed milk containing sugar finds its way into the market, packed in tin boxes containing from 450 to 500 grms. of the product.

Such condensed milk, evaporated, with the addition of more or less sugar, in a vacuum pan, contains, if the process is properly carried out, all the constituents of the milk unchanged as far as their chemical and physical properties are concerned; it differs from cows' milk merely by having lost some of the water, and the whole of the natural milk flavor. It is simply a prejudice that Swiss condensed milk should, as regards richness, possess superior qualities. Considerable stress is laid on the superior quality,

especially as regards flavor, of the milk of cattle fed on Alp-mountain pasture.

If we consider, however, that the establishments which manufacture condensed milk are not only situated in the valleys, but use exclusively, as they do everywhere else, milk produced in the valleys, the ridiculousness of the claims made for the purpose of *reclame* are at once apparent. These claims are equalled only by those proffered by the manufacturers of infants' milk-foods, who claim that their manufactures may fully compensate for the lack of breast milk. Provided that only good cows' milk is used, and that with an unvarying addition of sugar it is condensed to a proper and equal degree, no good reason exists why condensed milk produced in any other country should not be equal to that produced in Switzerland.

According to the season in which this milk is manufactured, the product differs in color. It is obtained whiter during the winter, more yellow during the summer. Condensed to a proper degree, it has the consistency of honey, and must, even after the boxes have been opened, remain in good condition, without change. Under such circumstances it should form a skin, consisting merely of dried milk constituents and sugar crystals, while the milk underneath should remain unchanged.

Sometimes such milk shows the consistency of cheese. This is produced by carrying the condensation too far. It shows then, frequently, odor and taste of rancid butter. Such milk is not completely disintegrated by water.

Physical Analysis.

The condensed milk boxes are generally opened on that end which is closed by one single tin sheet. For the purpose of examination, the boxes should be opened at the end where, through a hole in the center, the milk had been filled in, and which then had been closed by a separate cover, soldered air-tight to the box. We do this to ascertain whether the soldering has been perfect and has been performed without scorching the contents. To this end the cover is removed by cutting it on the circumference for about three-quarters.

The appearance of the milk is examined by removing some of the contents by means of a knife or spatule, and by observing it

against the light while it is allowed to run in a broad sheet back into the box.

Any imperfections, as the existence of more or less granules, of which good milk should contain but few, can thus be observed.

A good normal condensed milk should be of the consistency of honey; it should possess an agreeable flavor, and must be easily disintegrated, without the separation of a flocculent residue, by mixing it with from four to five parts of water. Only products prepared by deficient processes show abnormalities.

The microscope reveals the presence of butter globules, crystals of sugar, and groups of normal milk salt crystals.

Crystals of a moss-like structure are found in milk only when the process of condensation has been carelessly performed.

The microscopical observation is greatly facilitated if the condensed milk is brought upon the slide with a drop of oil, which will not affect the sugar crystals and salts. Cane sugar appears in large monoclinic prisms; milk sugar in four-sided tri-metric prisms; calcium lactate forms tufts of fine needles.

The specific gravity is determined in a flask of known weight and contents, in the manner described above.

Chemical Examination.

For the determination of the ***solids and ash***, two to three grms. of condensed milk are accurately weighed in a covered platinum crucible, coagulated by means of absolute alcohol, and treated as described on page 22.

Care must be taken that the sample is perfectly free from solder. Its presence would not only produce inaccurate results, but would destroy the platinum crucible when the solids are incinerated.

The albuminates and the fat are determined in two to three grms. accurately weighed in a covered beaker; 100 to 150 grms. of water are then added, the whole mixed thoroughly and precipitated with copper solution, as usual. From 1.5 to 2 c.c. of copper solution, and 0.75 to 1 c.c. alkali solution are required. The remaining part of the process of manipulation is the same as previously described (see page 24).

The determination of the cane sugar and milk sugar is made in such a manner that the latter is directly determined by means of

Fehling's solution, while the former is calculated. This method of determination by difference may well be accepted, considering the fact, that the rest of the constituents is determined by very accurate methods.

Well-preserved condensed milk of commerce varies in its composition according to the degree of concentration, the addition of cane sugar, and the season in which it has been manufactured.

The composition of condensed milk from different establishments varies as follows:

Water and volatile substances	20.0 – 30.
Salts	1.5 – 3.
Fat	8.0 – 12.
Albuminates	10.0 – 13.
Milk sugar	10.0 – 15.
Cane sugar	30.0 – 45.

Other Milk Preserves.

Condensed milk free from sugar, which is in general use in many large cities of the United States, where it is sold by measure from house to house, contains:

Water and volatile substances	46.5 – 55.
Salts	2.0 – 3.
Fat	13.0 – 20.
Albuminates	13.5 – 27.
Milk sugar	12.5 – 18.

The following ***specialties*** are also to be found in the market: cacao milk, coffee milk, medicated milk (N. G.), malt milk (N. G.) and salt milk, in which part of the cane sugar is replaced by salt. This latter is said to be employed in the manufacture of oleomargarine.

Lately, also, an article has been brought into the market, which is known in France as condensed Goudron milk, which is milk condensed with the addition of tar.

Condensed goats' milk, prepared by Gebr. Sigmond of Klausenburg, Germany, has, according to an analysis made by Godeffroy, the following composition:

Water and volatile substances	20.98
Salts	3.60
Fat	16.95
Albuminates	17.00
Milk sugar	15.72
Cane sugar	25.75

Preserved milk is generally prepared by Appert's process, which is known for the last forty years, and which consists mainly in boiling the milk, to destroy ferments, and keeping it then in hermetically sealed vessels.

Some methods of preservation by the use of chemicals are also practically employed.

The report of an analyst on the analysis of preserved milk should state:

1. Weight of can and milk, and weight of milk net, and if possible, the price of the article.
2. Trade mark and remarks as concerns untruthful claims made, etc.
3. Statement as regards the burning or scorching of the milk, when packed.
4. Consistency, color and flavor.
5. Results of the physical examination, including that by the microscope.
6. Results of the chemical analysis, arranged as given above.

Hygienic Demands.

The manufacturer should guarantee a certain chemical composition. Statements giving the average values in which the constituents are present, should be given with each package.

As yet, condensed milk has never been found to have been adulterated.

WOMAN'S MILK.

Woman's milk differs from the milk of animals, especially cows, not merely as regards the relative proportions in which the various constituents are present. There exist in some of these constituents marked differences regarding their chemical properties. The albuminates of woman's milk, for instance, behave differently towards precipitants. Woman's milk contains, according to the latest investigations of P. Radenhausen, no casein, but albumen, protalbumen and peptone, as they are found in the blood. This is the cause of the alkaline reaction of woman's milk. The milk loses its alkalinity, and shows then an amphotere reaction only, when larger quantities of protalbumen occur. The butter globules are in greater part free. With regard to these two points, woman's milk differs considerably from cows' milk, which is very rich in protalbumen. To these differences must be added, that woman's milk sours but slowly on account of its great alkalinity, and that the sugar predominates over the albumen.

The keeping qualities of woman's milk are such, that author has kept such milk during the summer, and during the winter near a stove, for from six to eight days before it curdled.

The appearance and composition of woman's milk differ considerably. Figures stating the composition are necessarily averages from a large number of examinations.

The secretion of woman's milk and its composition are considerably influenced by many circumstances, and more so than in the case of animals.

L. Fleischmann (Klinik der Paediatrik, vol. 1.) mentions the following:

1. ***Individual differences*** exert a certain but not a great influence upon the secretion and composition of the milk. Large breasts by no means indicate that the milk secreted by them is of good quality, as has been clearly demonstrated by the milk examinations untertaken by the author at the Bureau Central des Nourrices in Paris. Lean but well-nourished wet nurses produce frequently a richer

milk than fat nurses. Not much value should be attached to the color of the hair. A good healthy appearance and a happy disposition are of far greater importance.

2. ***The age:*** Women of the age of 20 to 30 years furnish generally the best milk.

3. ***The question of food,*** as regards its influence upon the milk, should be considered from various points. Unaccustomed but good food, taken for the purpose of exerting an influence upon the secretion of milk, has rarely accomplished what has been expected, *i. e.*, the secretion of better and richer milk. Different it is with animals, where a change in the food, from vegetable to animal diet, for instance, is at once followed by decided changes in the composition of milk.

If, however, the consumption of food is below the normal, and insufficient for the wants of infant and mother, either the one or the other must suffer.

4. ***Menstruation:*** The influence of menstruation upon the secretion of milk has long been overestimated. Even physicians consider it their duty to forbid the continuance of nursing on its recurrence. The examinations of Vernois and Becquerel have proved that such milk is richer in salts, albuminates and fat, and is, therefore, better. Only the quantity of the secretion is diminished.

5. ***Pregnancy:*** The continuance of nursing after the mother has again become pregnant is accompanied by grave consequences. Not only the mother and the child which she bears suffer, in consequence of the greater demands made upon the mother, but also the infant, whose supply of milk may be greatly diminished, if it does not fail altogether. An additional danger to the nursing child has also been found in the fact that such milk is apt to pass again through the stage where colostrum is the natural secretion (Bouchut). According to Davis' examinations, the solids which the milk contains are, with progressing pregnancy, gradually diminished, especially so the albuminates, fat and sugar.

6. ***The milk in various periods after birth*** is not equal in its composition. The first milk obtained at any one time from the breasts is generally thinner, while the last is the richest. A few days after birth the breasts yield colostrum, containing as yet granulated corpuscles, mucus and groups of butter globules. The

colostrum acts as a purgative. After the eighth day the milk appears normal to the naked eye, though it may contain a few colostrum corpuscles.

7. ***Sickness*** increases, in all cases, the milk solids, especially so in cases of chronic disease.

8. The influence of all kinds of ***psychic emotion*** upon the secretion of milk is well recognized.

9. The quality of the milk depends also on the ***number of children*** which the mother has borne, as also on ***the age of the previously born child,*** and the surroundings and circumstances of the mother. The milk from each of the two breasts differs, also.

All these circumstances must be considered and stated, if the examinations make claim to scientific accuracy.

10. ***Medicines*** taken by the mother may pass into the milk as they pass into cows' milk.

Abnormalities in milk are either caused by the lack or preponderance of one or more constituents, or by the presence of substances not found in normal milk.

Woman's milk has the following properties:

Smell: Hardly perceptible when from white women, but peculiar, and similar to the exhalations of the skin, in the case of women of the African race (Mott).

Taste: Sweeter than cows' milk, occasionally salty.

Color: Bluish-opaque.

Consistency: It is more watery than the milk of animals. Author found the milk, a few days or weeks after birth, rather rich in fat. The fat collects often in small globules on the surface; they possess an intensely yellow color, and are of such size that they may be seen with the naked eye.

Reaction: The reaction is, according to the latest investigations—which embraced the examination of one hundred and fifty samples—alkaline, provided the milk was tested directly after it had been obtained (Conrad, L. Fleischmann).

The ***specific gravity*** ranged in 130 observations from 1.025 to 1.039, at 15° C. (Conrad.)

Taking the Sample.

The time when a sample of milk is taken is by no means unimportant, and, in the case of woman's milk, presents some difficulties. Herbivora give their milk generally at stated periods; in the case of woman, however, it is different, and the taking of the sample is more difficult. With the report on an exact analysis, such data, giving the details with regard to the sampling, are indispensable.

Conrad proposes that the sampling be done, if possible, by the analyst himself, to prevent intentional or unintentional delusion. The best time for this is from two to three hours after the last nursing, when the breasts have filled again, and are ready for another nursing. The whole of the milk is then drawn, either by means of a breast pump, or by the use of forefinger and thumb, when it is collected in a clean, dry beaker. This latter manipulation can, with some practice, be conducted without causing the least pain, and is preferable to the use of the breast pump, since it brings the milk quicker, and because it furnishes better indications regarding the quantity of milk, and also its quality and consistency. By observing if the milk flows in thicker or thinner strains, valuable hints regarding the explanation of certain irregularities with reference to the nursing of the infant, and its digestion, may be obtained.

Thus, from 30 to 50 or 100, and sometimes even 200 c.c., of milk may be obtained. For really exact investigations, the milk from both breasts should be drawn and intimately mixed before the examination.

Physical Examination.

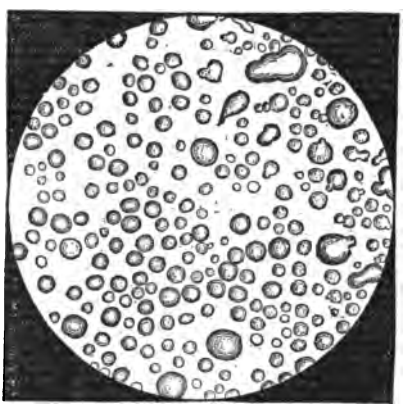
The ***specific gravity*** is determined for scientific purposes by means of a bottle of known weight and contents. For ordinary purposes, a lactodensimeter of Quevenne, of reduced size, may be used (Conrad's). They allow the determination of the specific gravity in from 30 to 40 c.c. of milk. The manipulation and calculation are the same as will later be mentioned in the chapter treating on "Milk inspection." For a better estimation of the quality of woman's milk, a determination of the fat by means of the lactobutyrometer should be made.

An apparatus for this and the determination of the specific gravity, neatly packed in a case and ready for use in hospitals, has been devised by Dr. F. Conrad, and its application been described by him in a pamphlet entitled "Die Untersuchungen der Frauenmilch fuer die Bedurfnisse der aerztlichen Praxis," Bern, 1880, J. Dalp.

Microscopical Examination.

It must not be attempted to determine the quantity of fat in woman's milk by means of the microscope. The difficulties which present themselves here are even greater than in the case of cows' milk.

The butter globules are scarce on the second day after delivery, while the granulated colostrum corpuscles predominate. Gradually the latter disappear while the former increase, until at about the sixth to eighth day after birth, they fill the whole field of vision quite densely. They appear of nearly uniform size, are round and highly refracting. The nourishing qualities of a milk depend on the quantity of fat globules, since milk sugar and albuminates increase in proportion. The presence and preponderance of very large butter globules indicates richness in fat. Such milk is more difficult to digest. Milk which contains badly-formed globules is lacking in nourishing qualities.

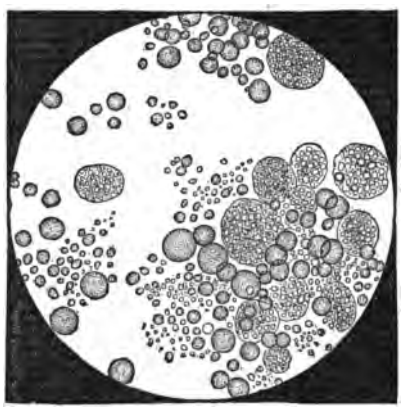


1. *Woman's Milk.*—The butter globules at the right upper part of the drawing appear irregularly shaped, produced by the action of acetic acid upon them.

Large globules are generally observed after a protracted period of nursing, and if the mother is advanced in age, an increase of the size of the globules has also been observed, and is then accompanied by the appearance of colostrum corpuscles at the period of menstruation, as also in cases of sickness accompanied by fever.

Very small globules predominate in the milk of insufficiently nourished or sick mothers. The children show then frequently symptoms indicating an insufficiency of food, as rachitis, atrophia, anaemia, leucaemia, etc.

Colostrum corpuscles may often appear in the milk, and betray, generally, sickness of the mother (feverish emotion, menstruation, etc.) If present in large numbers, they cause dyspepsia. Their occasional appearance is of no consequence.



Woman's Colostrum.

Blood Corpuscles are found in cases of inflammation of the breasts, excoriation, ulceration, etc.

Pus is found in cases of abscess of the parenchym of the glands.

Chemical Analysis.

The reaction is determined in such manner as has been described in cows' milk.

The methods of coagulation of albuminates and fat, as described by Hoppe-Seyler, Tolmatschoff, Brunner, Schukoffsky,

Christena and others, are well known and have been sufficiently discussed, that we may consider that our readers are sufficiently acquainted with their drawbacks, consisting partly in very tedious operations, partly in unreliable results. (See Fresenius' *Zeitschrift*, 1880; Petersen's *Forschungen*, 1879; Gerber und Radenhausen's Vorschlaege zu einer einheitlichen Untersuchungsmethode der Milch, *Schweizer Wochenschrift f. Pharmacie*, 1879.) The method employed by the author is a modification of the one proposed by Ritthausen for cows' milk. The albuminates of woman's milk differ from those found in other milks, especially, also, in their behavior to precipitants. A few c.c. of cupric sulphate solution precipitate the albuminates in 10 c.c. of cows' milk easily and completely, while in woman's milk but a part of the albuminates can thus be coagulated. By a modification of the process, however, complete coagulation can be obtained. To this end it is necessary to neutralize the acid in the sulphate almost or completely. Thus a fine flocculent precipitate is formed, which contains the fat and all the albuminates.

After a great many experiments the following method was adopted:

5 c.c. of woman's milk are diluted with 100 c.c. of distilled water, and after mixing well 3 c.c. (sometimes, perhaps more) of cupric sulphate solution are added, and then at once 2.5 to 3 c.c. of the alkali solution (strength of the respective solutions as given in the article on cows' milk). A precipitate is produced which sinks easily to the bottom of the beaker. For its further treatment we refer to the detailed description given in the chapter on the "Chemical analysis of cows' milk," p. 24.

The determination of the ***solids and ashes*** is made in 10 c.c. of accurately weighed woman's milk. The particulars for the examination of this milk do not differ from those described in the chapter on the "Analysis of cows' milk," to which we refer.

The difference in the ***composition*** of the milk of *white women* compared with that of *women of the African race*, has been given by H. A. Mott, jr. According to his statement, the secretion of the milk commences on the seventh or eighth day. The color of this milk is yellowish-white, resembling cows' milk. It is richer in solids than the milk of white women, and, on evaporation,

shows a distinct odor. The colostrum is similar to that observed with white women.

Milk of white women.	*Water.*	*Salts.*	*Fat.*	*Albuminates.*	*Milk Sugar*
Average of 14 Analyses (Tidy).....	87.806	0.285	4.021	3.523	4.265
" " 89 " (Vernois and Becquerel).....	88.908	0.138	2.666	3.924	4.364
Average of 14 Analyses (Simon).....	88.360	0.230	2.530	3.430	4.820
Milk of colored women.					
Average of 18 Analyses (Mott).....	86.340	0.600	4.030	3.320	5.710

AVERAGE.

	WOMEN.	
	White.	*Colored.*
Specific gravity.....	1.028 — 1.035	1.025 — 1.037
Water and volatile subst	88.0 — 90.0	86.0 — 90.0
Salts.....	0.2 — 0.5	0.3 — 0.75
Albuminates.....	2.0 — 4.0	1.3 — 4.0
Fat.....	2.5 — 5.0	4.0 — 5.0
Milk sugar	4.0 — 6.0	5.0 — 6.0

Average composition of colostrum:

Water.....	80.0 — 86.0
Salts.....	0.3 — 0.5
Albuminates.....	8.0 — 10.0
Fat.....	2.5 — 5.0
Milk sugar.....	4.0 — 5.0

The reports on the ***results of the examination of woman's milk*** must contain the items given, and also:

1. Specific gravity.
2. Reaction.
3. Age of woman, race, and color of hair.
4. Period of lactation; also, if the sample examined is from the right or left breast, or an average from both; quantity of milk obtained, and at what time after last nursing; time of day.
5. How often delivered.
6. Is menstruation present, or sickness?
7. Constitution.
8. Mother's support.
9. Health of infant.
10. Weight of infant, if it can possibly be obtained.

Milk from the Breasts of Newly-born Infants.

It frequently occurs that the breasts of newly-born infants contain considerable quantities of a secretion of the characteristics of milk (Hexenmilch). Slight pressure will furnish it in single drops. The microscope reveals the presence of real fat or milk globules, together with detached cells and colostrum corpuscles. It contains, according to an analysis made by Schlossberger:

Water	98.750
Salts	0.050
Albuminates	0.365
Fat	0.082
Milk sugar	0.065
	99.312

It has likewise been observed that men and male animals, in rare cases, yield a secretion from the breasts, resembling milk (Bock's milch).

INFANTS' MILK-FOODS

IN POWDER.

History: For the last ten or twelve years a food for infants, called milk-food, has been in the market. This was first prepared by a German, H. Nestle, in Vevey, Switzerland, and consists of prepared wheat flour and condensed milk. At the present time quite a number of milk-food factories are in existence, mainly in Switzerland, Germany and England, each of which works by a method of its own. The United States possesses but one establishment, and this only since 1881, under the management of the author.

Definition: All milk-foods are combinations of milk with specially prepared cereals and other flours. Other preparations, as maizena, flours of arrowroot, leguminosae, barley, rye and oats, should be sold as such to prevent the formation of the erroneous impression that they contain milk, and are intended as food for infants.

The following substances constitute the milk-foods of commerce:

1. Water and volatile (aromatic) substances.
2. Salts, especially alkalies and earths.
3. Milk fat and vegetable fat.
4. Milk albuminates and vegetable albuminates.
5. Soluble carbohydrates: milk and cane sugar, glucose, dextrine and soluble starch.
6. Insoluble carbohydrates and starch.
7. Cellulose in very small quantity.

The properties of milk-food are:

Odor normal: Agreeable, pastry-like.

Abnormal only when spoiled by age or exposure; it is then sour or mouldy. It may be decidedly rancid (tallow-like) from exposure or the use of moist flour in the manufacture. A slightly rancid odor disappears easily on boiling, and does in no way impair the use of the food. This odor is produced by the presence

of volatile acids of the fatty series, and forms readily in all milk products, especially those which are prepared with the aid of flour.

Taste: More or less sweet, mainly derived from the admixed condensed milk.

External normal appearance: Most foods appear as a more or less fine powder of a whitish to yellow color; lately they have also been brought into the shape of tablets, obtained by the application of high pressure.

Abnormal appearances: Vegetable mould and animalculæ are met with only in very old and carelessly exposed articles, especially when it had been packed in defective boxes, or when it had been kept in damp places.

Microscopical Examination.

This aims to recognize:

1. The general structure of the powder.
2. The butter globules of the milk.
3. Probable abnormal qualities.

The bulk of these milk-foods consists of carbohydrates which appear differently, according to their preparation previous to the admixture of the milk. They are either used in the crude state, or after being diastasized or baked.

Without going into the details of the questions of physiology and chemistry of starch, it will be well to give a few facts relating to this substance.

Starch heated with much water loses, already at a temperature of from 60 to 70° C., its peculiar characteristics by which it can, otherwise, easily be recognized under the microscope. Some kinds of starch show after careful roasting plainer and more easily recognizable properties than they possess when they are in the raw state. In examining a starch we can, therefore, use this process for the determination of their origin. The starch granules in bread generally retain their characteristics.

Careful heating to 100° C. increases the size of the granules. The structure and the navel become more distinct, and the shape becomes more round. Under the influence of a temperature of 150° C., most granules burst, and then the characteristic structure

disappears; those which stand the temperature without bursting, appear then smaller; structure and navel become indistinct and often unrecognizable.

The starch granules from the crust of English biscuits are generally somewhat smaller than those from the center, on account of the more direct influence of the heat upon the outside during baking. The same is the case with bread. The straight lines marking the strata appear, after roasting, wavy, caused by the irregular expansion of the layers. The presence of these wavy lines, when well defined, is decisive in the question whether the starch had been roasted or not. Frequently it is easier to decide whether a starch had been roasted at between 100 to 150° C., than to come to a decision regarding the origin of the starch.

The magnifying power of the microscope should, for these examinations, be not too small, since often minute details must be observed. It is also advisable to make all observations with the same lenses. The size of the granules is thus easier remembered and recognized, and the diagnosis thereby greatly facilitated.

A magnifying power of from 400 to 500 diameters is sufficient for all purposes.

Microscopical Examination for Carbohydrates.

To prepare a sample of milk-food for examination, the fat should first be removed from 0.5 to 1 grm. in the apparatus devised for fat determination, and described on page 26. Some of the substance is then brought on a slide, and mixed with one drop of a mixture of equal parts of glycerine and water. This mixture is preferred, since in pure water the granules swell too rapidly, while with pure glycerine no distinct picture can be obtained. Milk-food is very finely-ground, and it is, therefore, natural that not all the particles in the field of vision will show the required characteristics. These can safely be neglected, and it is, therefore, only necessary to observe such as will present sufficient characteristics for classification.

A microscopical examination is to be considered only as a qualitative, and never a quantitative, test in the case of milk-food.

The presence of starch can also be determined by the iodine reaction. The result thus reached is, however, too general and,

therefore, of little value. The characteristic forms of kinds of starch met with in the composition of milk-foods, are the following:

SAMPLES OF STARCH AS SEEN BY MEANS OF THE MICROSCOPE. MAGNIFYING POWER, 300 DIAMETERS.

Starch of Wheat.

Starch of Barley.

Starch of Oats.

Starch of Peas.

Starch of Beans.

This does not exclude that other kinds of starch and flours may be used. In exceptional cases it would, therefore, be well to make comparisons with the cuts as given in Hager, Die pharmaceutische Praxis; König, Nahrungs and Genussmittel, II.; Hassall, Adulteration of Food.

Microscopical Examination for Butter Globules.

The presence of condensed milk in milk-foods is easily recognized by the presence of butter globules. They appear under the

microscope as strongly refractive fat globules of varying size, which, on account of the protection afforded by the flour, do not easily unite, even after dilution with water.

To better distinguish them, a small quantity of the flour is brought on the slide, and then a solution of iodine in water (1 : 50) is added. Starch and dextrine are both distinctly colored, while the fat globules assume but a very slight yellowish tint on their extreme edge, and are easily recognized by their strong refractive powers. It occasionally happens that even starch granules are not colored by iodine, and may then be taken for fat globules. Addition of potash will swell these and dissolve them gradually, while the fat globules remain unaltered behind.

Eliza McDonogh, in her dissertation on milk-food, considered herself justified to conclude from the absence of sugar crystals in these foods, that no condensed milk had been used in their preparation, since this always shows sugar crystals. Miss McDonogh and Prof. Wyss would not have come to this conclusion if they had considered the method of manufacturing these foods, which totally differs from that of condensed milk. They even neglected to test these foods qualitatively for fat, and failed, on their microscopical examination, to recognize the butter globules. Their views are, therefore, without value. Owing to the process of manufacture, the butter globules are very finely divided and may, therefore, be easily taken for starch.

Beside the amylum and fat globules, the microscope will also reveal other normal constituents, the vegetable albumen and cellulose fragments.

Abnormal Constituents.

As abnormal constituents, fungi and the meal-mite may be found, which have their origin in the use of inferior flour.

Chemical Analysis.

The reaction of milk-food, after boiling with water, is acid. This is caused by the presence of large quantities of phosphates, and also by the presence of acids of the fatty series.

Determination of Water.

3 to 4 grms. of milk-food are taken from the center of a box

and accurately weighed in a previously weighed and covered platinum dish. They are carefully spread out by means of a spatule, which after use must always be cleaned by means of a small brush. They are then dried in an air bath at from 100 to 110° C., under frequent stirring. The dish and cover are placed in a dessicator to cool, and then weighed. This must be repeated until the weight remains constant.

Determination of the Ash and Phosphoric Acid.

The combustion for the determination of the ash must be carried out at as low a temperature as possible, so that none of the more volatile constituents of the ash are lost by volatilization. It is best to operate as follows: The whole is heated to complete carbonization of the contents, which are then transferred to a porcelain dish and extracted with water. The solution is then filtered off. The filter and the residue upon it are then again transferred to the platinum dish and, after drying, incinerated. The water solution, unless it be preferred to determine it separately, is then, together with the ashes, evaporated to dryness, then heated to a dull red heat, and allowed to cool in a dessicator. It is then weighed.

The determination of the phosphoric acid is carried out after the manner described on page 23.

Determination of Fat.

Some of the milk-food from the center of the box is placed into a dry stoppered test tube, which is weighed. From 2 to 3 grms. are then brought upon a dry filter resting in a small funnel. The tube is then re-weighed, the difference being equal to the quantity placed upon the filter. The funnel, with contents, is then dried in an air bath, at from 80 to 100° C., for a short time, to remove the bulk of the moisture. Filter and substance are then transferred from the funnel to the funnel belonging to the apparatus described by the author for the determination of the fat. This funnel is then adjusted to the weighed flask, and ether, free from alcohol, is poured upon the filter, care being taken that none of the food is carried over the edges of the filter. When the flask is about half filled with ether, the apparatus is connected, and the

flask heated so that the filter is continually immersed to about one-half its height in condensed ether. The complete extraction of the fat requires from one to two hours' treatment. The ether is then carefully distilled off, the last traces being removed by heating in an air bath at from 100 to 110° C., while the flask is placed into a horizontal position. After cooling in the dessicator, the flask is weighed, the increase corresponding to the amount of fat contained in the quantity of sample taken.

Determination of the Soluble Carbohydrates.

In the determination of the soluble carbohydrates, it is of importance that the directions for use, as established by the manufacturer, should be carefully considered. The manufacturer's claim in regard to this is fully justified by the fact that more soluble carbohydrates are contained in the food after its preparation, according to the directions, than are contained in the food previous to such preparation. The value of an analysis which gives the composition of the food as it is employed, is, likewise, the only guide which a physician has for the determination of the value of a milk-food.

In the case of milk-foods containing diastase, we take 1 part of milk-food and 10 parts of distilled water, and treat this mixture carefully according to directions. In other respects, the method of analysis is the same as for other milk-foods.

In the case of ordinary milk-foods, we take for 1 part 10 parts of water, or for from 2 to 3 grms., the ordinary quantity taken, from 20 to 30 c.c. water. The mixture is then heated to boiling, and kept boiling for five minutes with continual stirring. It is then allowed to cool. This process should be accelerated by blowing and stirring, to prevent the formation of a skin on the surface. This part of the operation is best carried out in a porcelain or platinum dish, which should be large enough to conveniently hold the double quantity of the fluid used. After cooling, the contents are transferred to a beaker of 150 to 200 c.c. contents, the material adhering to the sides of the vessel being carefully washed with 100 c.c. alcohol, of 50° Tr., into the beaker, so that the sediment therein is not disturbed. The whole is allowed to stand over night. The clear fluid is then first drawn off by means of a siphon and filtered through a dry filter. Finally the precipitate is washed on the filter

with 100 c.c. alcohol of 50° Tr. The filtrate is thus brought to about 220 c.c. It is then carefully evaporated on a water bath to about 50 c.c., refiltered, when necessary, and finally evaporated to dryness in a weighed platinum dish. The drying is finished in an air bath at from 100 to 110° C., and is to be continued until no further loss of weight is observed. To facilitate the drying, it is well to add to the solution, which has been concentrated to about 10 c.c., some absolute alcohol from time to time, whereby the carbohydrates are precipitated, and then to spread the mass over the sides of the dish by means of a spatule. Evaporation is thus greatly accelerated. When constant weight has been reached, the contents of the dish are incinerated, and, after deducting weight of dish and ashes from the weight first determined, we obtain the weight of the soluble carbohydrates.

Determination of Insoluble Carbohydrates.

The residue from the alcohol treatment is transferred into a flask of 400 c.c. contents, and then 200 c.c. of water and 20 c.c. pure hydrochloric acid are added. Loosely covered with a cork, the flask is inserted into the water of a boiling water bath, and kept there for from three to four hours. The inversion will be completed by this time. The contents of the flask are then carefully neutralized, whereby any albumen which may have gone into solution under the influence of heat and acid, is precipitated. The neutralized solution is then filtered through a ribbed filter, flask and filter being washed until the filtrate measures 500 c.c. The amount of sugar in this solution is determined by Fehling's solution as previously described. For the calculation of starch, Sachsse's figures, 108 glucose — 99 starch, have been accepted.

CALCULATION.

Supposing that 2.093 grms. substance had been used for the determination of soluble and insoluble carbohydrates, and that, of the sugar solution obtained by inversion, 28 c.c. had been required for 5 c.c. Fehling's solution, we would find the starch by the following equations:

28 : 0.025 — 500 : X or X — 0.44
108 : 99 — 0.44 : X or X — 0.403
2.093 : 0.403 — 100 : X or X — 19.24

per cent. of insoluble carbohydrates (amylum).

Cellulose: A method for the accurate determination of cellulose is not known. For practical purposes, it is generally sufficient to estimate it as being present to the extent of 0.5 per cent.

Determination of the Albuminates.

It has been customary to calculate the albumen and albuminoids in milk-foods by determining the nitrogen. The figure obtained for nitrogen was then multiplied by 6.25, it having been accepted that the nitrogenous part contained 16 per cent. of nitrogen. This presumption is false. The nitrogenous substances going into the composition of milk-food contain from 15.5 to 18.5 per cent. of nitrogen. From this it is evident that results reached by the determination of the nitrogen cannot be accurate, and it is, therefore, useless to speculate as to the method, which in this case is to be preferred, Dumas' or Will-Varrentrapp's. For all the other constituents sufficiently accurate methods exist. Albumen is, therefore, here as in the case of condensed milk, determined by difference.

Reports on Milk-foods.

must contain:

General description: Gross and net weight of packages, their suitability, and, if possible, the price.

Description of trade mark: Remarks on fancy claims upon the labels, as would be, for instance, the claim of a complete substitute for breast milk, etc.

Physical description: Appearance, odor, taste, microscopical examination.

The chemical analysis should state:

Water and volatile substances.
Salts (phosphoric acid).
Fat.
Albuminates.
Soluble carbohydrates.
Insoluble carbohydrates.
Cellulose.

Statement giving the analytical method by which these results were obtained.

Hygienic Demands of the Manufacturers of Milk-foods.

The German society, "Fuer oeffentliche Gesundheitspflege," has rightfully demanded that each manufacturer of milk-food shall attach to each package of his food an analysis stating the average quantities in which its constituents are present. It would be very desirable if the sanitary authorities of all countries would adopt and carry out such measures for the benefit of the health of infants, who depend upon this food. Why should the manufacturer of milk-food not be held equally responsible as dealers in milk and other food substances?

The various milk-foods in the market vary in composition as follows:

		Average.
Water.....	5.0 to 10. per cent.	7.50
Salts.....	1.5 to 3. "	2.25
Fat.....	4.0 to 7. "	5.50
Albumen.....	9.5 to 18. "	13.25
Sol. carbohydrates....	35.0 to 55. "	45.00
Insol. " ...	15.0 to 35. "	25.00
Cellulose.....	0.5 to 1. "	0.75
		99.25

From this it is evident that the various brands of milk-food vary considerably. The greatest variations among solids exists in the albuminates and insoluble carbohydrates, which differ in the first almost, and in the second over, 100 per cent. This is, no doubt, a considerable difference, and must greatly influence the prosperity of the infant depending on these foods for nourishment, as it should the buyer, who, in most cases, will have to pay the same price, be the food a good or an inferior article.

This desired interference of the sanitary authorities is, however, not meant as consisting in the upholding of ideal desires, which practically cannot be realized. What is wanted is a food which in its composition, *i. e.*, the relations of the constituents, resembles breast milk, and which is distinguished by its stability.

In considering what has practically been done in this field of manufacture, we can safely say that the possibility of the solution

of this problem has practically been proved by some manufacturers in Switzerland and Germany. It is also a fact that now even better preparations are in the market than correspond to the average composition given above.

In the face of these facts, it is astonishing that the milk-food of least rational composition, Nestle's, is yet the one which physicians generally recommend. Analyses of five chemists: F. Hofmann, J. König, Müller, P. Radenhausen and N. Gerber, give for the same, on the average, the following composition:

	Nestle's.	*Average of all Milk-foods.*
Water	6.74	7.50
Salts	1.77	2.25
Fat	4.20	5.50
Albuminates	9.75	13.25
Carbohydrates	76.92	70.00

The difference in the most important factor, the albumen, is sufficient to show the great improvements made by others.

Author considers it of vital importance that a rationally compounded infants' milk-food should contain at least

2 per cent. salts,
5 per cent. fat, and
13 per cent. albuminates,

and that manufacturers should be compelled to adopt this standard.

Practice has taught that such milk-foods can be manufactured. Careful investigations have proved that, for a rational food, it is of greater importance to adhere to a certain proportion of albumen, fat, and salts, to the carbohydrates, than to consider the shape in which these carbohydrates are presented. It is for this reason that the author is in favor of the relations of the main constituents as they have been given above.

Indigestion with children will increase, when a food is lacking in albumen, but contains, in its place, soluble carbohydrates; the first is, therefore, of greater importance than the latter.

If a sanitary governmental control of milk-foods should be introduced, as it has been done already for milk, it is evident that each manufacturer will be compelled to work better and on a more rational plan, than is frequently done at the present time. It is

then to be hoped that the expressions of Albu, of Berlin, and Jacobi, of New York, to the effect that these manufacturers work, not for the welfare of mankind, but for their own purse, will cease to be true.

It is evident that these two physicians do not value the combined efforts of chemical science and capital very highly; yet those who think differently should be on their guard, that they do not allow themselves to be blinded by either *reclame* or fame of manufacturers who have failed to adapt their products to the progress of our knowledge.

The packing of the article should be such that it reaches the market in good condition in every respect.

If, on the statement of physicians or sanitarians, the article is found to be not in a perfect condition, the manufacturer ought to be notified before the results of such inspection are made public, since it frequently happens that these preparations are not stored with those precautions which are required to insure that they reach the consumer in a good state.

GOVERNMENTAL CONTROL OF THE MILK SUPPLY.

The question of how the milk supply of cities should be brought under government control, has of late so frequently been discussed, that we propose to give here merely fundamental explanations, but based upon extended experience of the matters connected with the hygiene of milk. The milk reaches our markets in a variety of conditions; sometimes it is the natural product; sometimes it has been skimmed or watered; sometimes both processes have been resorted to; sometimes the milk is fresh, good-flavored, and shows good keeping qualities; but frequently it is stale, of bad taste, and apt to get sour. The vessels used for transporting it are not always the cleanest, and often no precautions are taken to keep it cool while it is transported or stored.

For these reasons, it is not to be wondered that the inhabitants of cities do not use this otherwise excellent food to such an extent as they should and might, if they had the guarantee that only a rich, cleanly-treated, well-flavored, and unchanged milk would be offered them.

Milk is a product of rather complicated composition; and it is, by no means, an easy task to ascertain the quantities of the valuable constituents which it contains. It is, therefore, of the greatest importance to the inhabitants of especially the larger cities to know that the products which reach the market have to pass sanitary inspection.

In most of the larger cities, this control has been assumed by the government; but it is frequently carried out, not only in an unrational, but also a very superficial manner. Science and justice are certainly not furthered when, even now, milk is passed or condemned merely upon the results obtained by the use of the lactodensimeter alone, or in combination with a cremometer. While many dealers, by the use of such primitive methods, have escaped the deserved punishment, others, who were entirely innocent, have been punished. It is, therefore, at the time, and, in the interest

of sanitary welfare, that the composition of a normal milk be defined, for the purpose of establishing a sure guide for rational milk inspection.

It is our purpose to establish such points as may be deduced from many years' practical experience and a strictly scientific treatment of the entire subject.

To pronounce a milk as good, bad, or adulterated, can, doubtless, be done only by regarding special laws, which must be obtained by careful observation and thousands of examinations, including the different races living under varying circumstances in various countries, and under the influence of different climates. But despite this well-acknowledged requirement, we meet everywhere with the passage and promulgation of ordinances which are in direct opposition to this only rational plan. Such ordinances, therefore, not only cause the drawing of false deductions, but, also, the use of more serious adulterants.

This wrong is frequently committed by professors and others, who, proud of their general learning, are frequently ignorant even of the most exact methods of analysis, or of the latest investigations regarding milk, or the practice of dairy industry. The dairy industry and governmental milk control require, at the present time, as well specialists as there exist in other branches of applied chemistry.

It is the practical specialist, and not the professor, who must decide in cases before the courts. In the examination of milk, it must always be considered that a difference exists between milk, in its physiological bearing, and market milk; for while, in the first, the constituents may be present in greatly varying proportions, we may demand, in the latter, a maximum and minimum quantity of the whole, and all the single food substances which constitute milk.

The question how a market milk—which is generally the yield of several cows mixed—may vary, has, for many localities, not yet been determined. It is, therefore, of importance, when it is contemplated to introduce government control, that the milk of many cows and whole dairies be frequently examined, so that, for these localities, average figures may be obtained, which may serve as a guide. Average figures should, however, be only calculated from such examinations as comprise the yield of whole dairies, and not only examinations which are made of the milk of single cows.

While, as yet, the average figures obtained by the examination of the mixed milk of cows supplying one dairy, has, in all countries, been the same, we find frequently in the milk of single cows great abnormalities, caused by the influence of race, age, constitution, food, time of milking, heat, quantity, season, or whether the cows are on pasture or housed.

Another desideratum of importance is the method by which analytical results are obtained. They must naturally be exact, and the examinations must be continued for a considerable time, care being taken that physiological and pathological data are carefully noted. This is, unfortunately, frequently omitted.

To facilitate a control of the market milk, on the part of the authorities, it becomes, therefore, necessary that the limits of composition of a normal milk, and its physical properties, be defined, in order to avoid reproach and tedious explanation. To fix such limits is, however, not without danger. If we ask too much, we risk that unjust sentences are administered, and, moreover, that the judge will be tempted to be exceedingly lenient in such cases. If we lower the standard too much, we risk that adulterations of minor extent escape punishment.

Our own standard, which is based upon thousands of examinations made by various investigators, and which has been practically proved as good and just, will be given further on.

It has previously (see page 39) been stated that the adulteration of milk may be practised by the following means:

1. Addition of water.
2. Skimming.
3. Skimming and addition of water.
4. Mixing of skimmed milk with whole milk.
5. Addition of foreign substances, to prevent detection of milk adulterated by any of the processes in 1 to 4.

Watering and skimming, and the mixing together of such deteriorated products, or the mixing with whole milk, are the ordinarily practised means of adulteration. Other substances than water are rarely employed, and then only when it is intended to re-establish a normal appearance of milk which has either been adulterated or which is naturally inferior. The substances used for this purpose have been enumerated on pages 41–43, where also the methods are given by which they may be detected.

The so frequently praised microscopical examination is of little value unless it be for the determination of foreign substances, as blood, pus, colostrum, detritus, etc., or solid adulterants. For the determination of the percentage of fat, it is without value, though it is correct, that a milk shows the butter globules in all the sizes as they are recognized to occur in normal milk, but further apart, when it had simply been watered. The want of the larger and medium-sized globules may indicate skimming, since the larger globules are known to rise sooner and easier. They are the first to form the cream, and disappear, therefore, with the removal of this first-formed cream.

The greatest difficulty exists in getting uniform samples for microscopical examination, as was first shown by Conrad, who has proved that, in examining woman's milk, even the same sample, carefully mixed and sampled by an arrangement to control the quantity taken for one slide, will give results showing differences in number, size and distribution of the fat globules. The methods used for estimating the number of globules are, moreover, arbitrary and uncertain. We will later on give a more satisfactory method for the determination of fat.

Determination of Specific Gravity.

The specific gravity of milk depends upon three points: The substances, as milk sugar, salts and albuminates, dissolved or contained in the water which forms part of the milk, in a diffused, gelatinous condition, increase the specific gravity, while the suspended fat globules diminish it. Increase of temperature diminishes the specific gravity likewise, while decrease of temperature will increase it. The specific gravity is determined, for practical purposes, with sufficient accuracy, by the use of a milk areometer, the so-called lactodensimeter.

It should be remarked here that the name *lactometer*, which has been given to these instruments, *is wrong*, and should certainly not be used by scientifically educated persons. It conveys a wrong impression; for, to this day, we have no instrument, and least in the lactodensimeter, which furnishes us a direct measure for the quality of the milk.

The best and most exact instruments are those of Quevenne, the inventor of the lactodensimeter, which give, in abbreviated

figures, *directly the specific gravity.* All other instruments, with scales differing from this, have been abolished on the European continent. It is only in England, and through English influence in America, that instruments with arbitrary scales are as yet in use. The principle upon which these are constructed is a wrong one, and they possess, moreover, useless appendages. It is never required to use the lactodensimeter for degrees below a specific gravity of 1.015, and all those degrees below this are, therefore, useless. The scale appears long, but its actually useful part is exceedingly short.

Quevenne's areometer has, for the specific gravities of from 1.015 to 1.040, on a scale of 5.5 c.m. length, 25 degrees, and allows thus easily the reading of half degrees; while a so-called lactometer has, on a scale of 7.8 c.m., 120 degrees, with a space of 0.065 c.m. for each degree. For milk, this subdivision lays below the actual possibility of accurate reading.

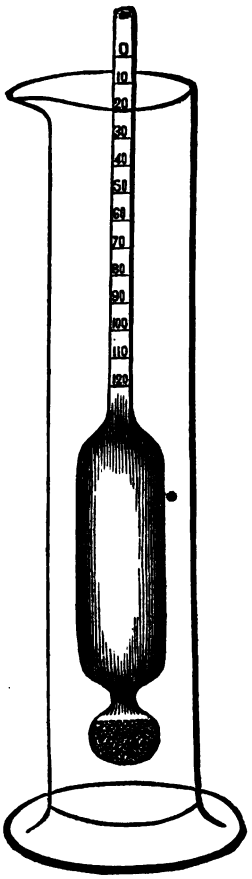
The reason that such areometers, with arbitrary scales, have remained in use for so long a time, is explained by the fact, that men without intimate knowledge of the subject, and without desire to obtain it, find it easier to go on with their investigation by making a so-called authority responsible for their results, without considering that many of these so-called authorities frequently adhere to and defend their wrong positions, even after they have been proved to be untenable.

Another drawback for the practical application of those lactometers is to be found in the fact that no tables exist for the correction of the error created by the reading of the instrument at a temperature which is not the normal temperature. Every sample *must* be cooled or warmed to 60° F. The usefulness of the instrument is thereby considerably lessened.

Description of Quevenne's Lactodensimeter.

The lactodensimeter of Quevenne is an ordinary areometer. It is made of glass, and is 22 c.m. long. It consists of a hollow body, kept in an upright position by a weighted globe at its under end; above, it carries the 6 c.m. long stem which bears the scale.

The dimensions of the instrument are chosen to insure sufficient ease of motion and to prevent unnecessary length of stem.



Centesimal Galactometer, or Lactometer.

Quevenne's Lactodensimeter.

It is weighted to such an extent, that it sinks in a salt solution of 1.042 specific gravity, at 15° C., to a point which is marked 42. Milk mixed with half its volume of water has a specific gravity of 1.014 to 1.016. Therefore, a second point is determined by putting the areometer in a salt solution of 1.014 specific gravity, at 15° C. This point is marked 14. The space between 14 and 42 is then divided by lines in 28 equal parts, or degrees. The distance between each two degrees is about 2 m.m. It is, therefore, not difficult to read the specific gravity easily to 0.0005 with sufficient accuracy.

The lactodensimeter of Quevenne-Müller bears the scale in a brass tube, and is, therefore, preferred by those who find the working with glass instruments unprofitable. It bears two scales—the one to the right to be used for whole milk, and the one to the left for skim milk.

The meaning of the fractions on the right — $\frac{1}{10}$ (29 — 26), $\frac{1}{10}$ (26—23), etc.—is that the addition of water to whole milk is about as corresponds to these fractions. On the left of the scale the same is repeated, but the fractions appear in different places, 32.5 — 36.5, corresponding to normal unwatered skim milk. The fractions on the left stand about 4 degrees lower on the scale, for the reason that the specific gravity of milk gains 4 degrees by the process of skimming.

This double scale allows of a far more extended application of the lactodensimeter than those which only give the specific gravity.

It would, perhaps, be even better to construct the densimeters with a scale ranging from 1.020 to 1.040, and divide these 20 degrees over the space occupied by 28 degrees. The reading of subdivisions of degrees would thereby be greatly facilitated. This, from a practical point of view, is easily justified by the fact that, in doubtful cases, at any rate, all milks showing specific gravities outside of the limits 1.027 to 1.033, must be analyzed.

It is, likewise, to be recommended to have the thermometer inclosed into the areometer, as is done with those which are manufactured in Germany.

Each lactodensimeter must be carefully examined for its accuracy, by comparing the results obtained with it with those obtained by means of a specific gravity bottle, and only instruments giving correct readings for at least three decimals should be employed.

Determination of the specific gravity: The apparatus necessary for this are:

1. A well adjusted and examined lactodensimeter of Quevenne, with or without inclosed thermometer.
2. An accurate Celsius thermometer.
3. Glass cylinders sufficiently high and wide to admit of the introduction and use of the lactodensimeters.

A.—*Examination of whole milk and market milk:* 1. The milk is well mixed and poured into a cylinder, care being taken that the milk runs slowly down its sides, by holding it in a somewhat inclined position. Thus the formation of foam, which would materially interfere with accurate readings, is prevented.

2. The thermometer remains in the milk for about two minutes before the temperature is quickly read and noted. If the milk be fresh from the cow, it should be cooled by holding the cylinder containing it in cold water. The thermometer is thereby used for stirring the milk slowly, and for observing the gradual reduction of temperature, which is brought as near as practicable to 15° C. (59° F.) If, on the other hand, the temperature of the milk, as during winter time, is very low, it must be gradually raised to from 15 to 20° C.

3. The stem of the lactodensimeter, which bears the scale, is, to prevent adhesion and to enable a more accurate reading, drawn between the closed lips, and then inserted into the milk until its surface reaches the degree marked 30. It is then liberated to find its level. If it should swim without changing its position, it is pushed from one to two degrees deeper, and again liberated to find its level. If the same reading is obtained, the degree is noted.

4. All readings of the lactodensimeter give accurate density only at a temperature of 15° C. Warmer milk is lighter; colder, on the contrary, heavier. If the density has been observed at another temperature, the actual density is found in the following first table for whole milk, by using it in the following manner:

The first vertical column of figures gives the degrees of the lactodensimeters read directly. The first horizontal line gives the degrees of the Fahrenheit thermometer, the second the corresponding degrees on the Celsius thermometer. In order to find the real density, we pass from the degree of the lactodensimeters read, to the right, until we reach the column headed by the degree of temperature observed. The figure at the intersection of both lines gives actual density at 15° C. If, for instance, we found 28° on the lactodensimeter, at 18° C., we would thus find actual density at 15° C. — 28.6° — to a specific gravity of 1.0286.

Table for the Correction of Error caused by the Reading of the Lactodensimeter at other Temperatures than 15° C. for Whole (not Skimmed) Milk.

TEMPERATURES.

°F	32.0	33.8	35.6	37.4	39.2	41.0	42.8	44.6	46.4	48.2	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4	84.2	86.0
°C	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
14	12.9	12.9	12.9	13.0	13.0	13.1	13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	14.0	14.1	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8
15	13.9	13.9	13.9	14.0	14.0	14.1	14.1	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	15.0	15.1	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8
16	14.9	14.9	14.9	15.0	15.0	15.1	15.1	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	16.0	16.1	16.3	16.5	16.7	16.9	17.1	17.3	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9
17	15.9	15.9	15.9	16.0	16.0	16.1	16.1	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	17.0	17.1	17.3	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	20.0
18	16.9	16.9	16.9	17.0	17.0	17.1	17.1	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	18.0	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	21.0
19	17.8	17.8	17.8	17.9	17.9	18.0	18.1	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	19.0	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	22.0
20	18.7	18.7	18.7	18.8	18.8	18.9	19.0	19.0	19.1	19 2	19.3	19.4	19.5	19.6	19.8	20.0	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7	23.0
21	19.6	19.6	19.7	19.7	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.1
22	20.6	20.6	20.7	20.7	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.8	22.0	22.2	22.4	22.6	22 8	23.0	23.2	23.4	23.6	23.8	24.1	24.3	24.5	24.7	24.9	25.2
23	21.5	21.5	21.6	21.7	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2	24.4	24.6	24.8	25.1	25.3	25.5	25.7	26.0	26.3
24	22.4	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.8	24.0	24.3	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.1	26.3	26.5	26.7	27.0	27.3
25	23.3	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1	24.2	24.3	24.5	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.0	26.2	26.4	26.6	26.8	27.1	27.3	27.5	27.7	28.0	28.3
26	24.3	24.3	24.4	24.5	24.6	24.7	24.8	24.9	25.0	25.1	25.2	25.3	25.5	25.6	25.8	26.0	26.2	26.4	26.6	26.9	27.1	27.3	27.5	27.7	27.9	28.2	28.4	28.6	28.9	29.2	29.5
27	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0	26.1	26.2	26.3	26.5	26.6	26.8	27.0	27.2	27.4	27.6	27.9	28.2	28.4	28.6	28.8	29.0	29.3	29.5	29.7	30.0	30.3	30.6
28	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26 8	26.9	27.0	27.1	27.2	27.4	27.6	27.8	28.0	28.2	28.4	28.6	28.9	29.2	29.4	29.6	29.9	30.1	30.4	30.6	30.8	31.1	31.4	31.7
29	27.0	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27 9	28.1	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.9	30.2	30.4	30.6	30.9	31.2	31.5	31.7	31.9	32.2	32.5	32.8
30	27.9	28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	29.0	29.2	29.4	29.6	29.8	30.0	30.2	30.4	30.6	30.9	31.2	31.4	31.6	31.9	32.2	32.5	32.7	33.0	33.3	33.6	33.9
31	28.8	28.9	29.0	29.1	29.2	29.3	29.5	29.6	29.7	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.7	32.0	32.3	32.5	32.7	33.0	33.3	33.6	33.8	34.1	34.4	34.7	35.1
32	29.7	29.8	29.9	30 0	30.1	30.3	30.4	30.5	30.6	30.8	31.0	31.2	31.4	31.6	31.8	32.0	32.2	32.4	32.7	33.0	33.3	33.6	33.8	34.1	34.4	34.7	34.9	35.2	35.5	35.8	36.2
33	30.6	30.7	30.8	30.9	31.0	31.2	31.3	31.4	31.6	31.8	32.0	32.2	32.4	32.6	32.8	33.0	33.2	33.4	33.7	34.0	34.3	34.6	34.9	35.2	35.5	35.8	36.0	36.3	36.6	36.9	37.3
34	31.5	31.6	31.7	31.8	31.9	32.1	32.2	32.3	32.5	32.7	32.9	33.1	33.3	33.5	33.8	34.0	34.2	34.4	34.7	35.0	35.3	35.6	35.9	36.2	36.5	36.8	37.1	37.4	37.7	38.0	38.4
35	32.4	32.5	32.6	32.7	32.8	33.0	33.1	33.2	33.4	33.6	33 8	34.0	34.2	34.4	34.7	35.0	35.2	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.1	39.5

Table for the Correction of Error caused by the Reading of the Lactodensimeter at other Temperatures than 15° C. for Skimmed Milk.

TEMPERATURES.

°F	32.0	33.8	35.6	37.4	39.2	41.0	42.8	44.6	46.4	48.2	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4	84.2	86.0
°C	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
18	17.2	17.2	17.2	17.2	17.2	17.3	17.3	17.3	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.4	18.6	18.8	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7
19	18.2	18.2	18.2	18.2	18.2	18.3	18.3	18.3	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.1	19.2	19.4	19.6	19.8	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7
20	19.2	19.2	19.2	19.2	19.2	19.3	19.3	19.3	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.4	20.6	20.8	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7
21	20.2	20.2	20.2	20.2	20.2	20.3	20.3	20.3	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.4	21.6	21.8	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.3	23.5	23.7
22	21.1	21.1	21.1	21.1	21.2	21.3	21.3	21.3	21.3	21.4	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.4	22.6	22.8	22.9	23.1	23.3	23.5	23.7	23.9	24.1	24.3	24.5	24.7
23	22.0	22.0	22.0	22.0	22.1	22.2	22.3	22.3	22.3	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.4	23.6	23.8	23.9	24.1	24.3	24.5	24.7	24.9	25.1	25.3	25.5	25.7
24	22.9	22.9	22.9	22.9	23.0	23.1	23.2	23.2	23.2	23 3	23.4	23.5	23.6	23.7	23.9	24.0	24.1	24.2	24.4	24.6	24.8	24.9	25.1	25.3	25.5	25.7	25.9	26.1	26.3	26.5	26.7
25	23.8	23.8	23.8	23.8	23.9	24.0	24.1	24.1	24.1	24.2	24.3	24.4	24.5	24.6	24.8	25.0	25.1	25.2	25.4	25.6	25.8	25.9	26.1	26.3	26.5	26.7	26.9	27.1	27.3	27.5	27.7
26	24.8	24.8	24.8	24.8	24.9	25.0	25.1	25.1	25.1	25.2	25.3	25.4	25.5	25.6	25.8	26.0	26.1	26.3	26.5	26.7	26.9	27.0	27.2	27.4	27.6	27.8	28.0	28.2	28.4	28.6	28.8
27	25.8	25.8	25.8	25.8	25.9	26.0	26.1	26.1	26.1	26.2	26.3	26.4	26.5	26.6	26.8	27.0	27.1	27.3	27.5	27.7	27.9	28.1	28.3	28.5	28.7	28.9	29.1	29.3	29.5	29.7	29.9
28	26.8	26.8	26.8	26.8	26.9	27.0	27.1	27.1	27.1	27.2	27.3	27.4	27.5	27.6	27.8	28.0	28.1	28.3	28.5	28.7	28.9	29.1	29.3	29.5	29.7	29.9	30.1	30.3	30.5	30.7	31.0
29	27.8	27.8	27.8	27.8	27.9	28.0	28.1	28.1	28.1	28.2	28.3	28.4	28.5	28.6	28.8	29.0	29.1	29.3	29.5	29.7	29.9	30.1	30.3	30.5	30.7	30.9	31.1	31.3	31.5	31.7	32.0
30	28.7	28.7	28.7	28.7	28.8	28.9	29.0	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.8	30.0	30.1	30.3	30.5	30.7	30.9	31.1	31.3	31.5	31.7	31.9	32.1	32.3	32.5	32.7	33.0
31	29.7	29.7	29.7	29.7	29.8	29.9	30.0	30.0	30.1	30.2	30.3	30.4	30.5	30.6	30.8	31.0	31.2	31.4	31.6	31.8	32.0	32.2	32.4	32.6	32.8	33.0	33.2	33.4	33.6	33.9	34.1
32	30.7	30.7	30.7	30.7	30.8	30.9	31.0	31 0	31.1	31.2	31.3	31.4	31.5	31.6	31.8	32.0	32.2	32.4	32.6	32.8	33.0	33.2	33.4	33.6	33.9	34.1	34.3	34.5	34.7	35.0	35.2
33	31.7	31.7	31.7	31.7	31.8	31.9	32.0	32.0	32.1	32.2	32.3	32.4	32.5	32.6	32.8	33.0	33.2	33.4	33.6	33.8	34.0	34.2	34.4	34.6	34.9	35.2	35.4	35.6	35.8	36.1	36.3
34	32.6	32.6	32.6	32.7	32.8	32.9	32.9	33.0	33.1	33.2	33.3	33.4	33.5	33.6	33.8	34.0	34.2	34.4	34.6	34.8	35.0	35.2	35.4	35.6	35.9	36.2	36.4	36.7	36.9	37.2	37.4
35	33.5	33.5	33.5	33.6	33.7	33.8	33.8	33.9	34.0	34.1	34.2	34.3	34.4	34.6	34.8	35.0	35.2	35.4	35.6	35.8	36.0	36.2	36.4	36.6	36.9	37.2	37.4	37.7	38.0	38.3	38.5
36	34.4	34.4	34.5	34 6	34.7	34.8	34.8	34.9	35.0	35.1	35.2	35.3	35.4	35.6	35.8	36.0	36.2	36.4	36.6	36.9	37.1	37.3	37.5	37 7	38.0	38.3	38.5	38.8	39.1	39.4	39.7
37	35.3	35.4	35.5	35.6	35.7	35.8	35.8	35.9	36.0	36.1	36.2	36.3	36.4	36.6	36.8	37.0	37.2	37.4	37.6	37.9	38.2	38.4	38.6	38.8	39.1	39.4	39.6	39.9	40.2	40.5	40.8
38	36.2	36.3	36.4	36.5	36.6	36.7	36.8	36.9	37.0	37.1	37.2	37.3	37.4	37.6	37.8	38.0	38.2	38.4	38.6	38.9	39.2	39.4	39.7	39.9	40.2	40.5	40.7	41.0	41.3	41.6	41.9
39	37.1	37.2	37.3	37.4	37.5	37.6	37.7	37.8	37.9	38.0	38.2	38.3	38.4	38.6	38.8	39.0	39.2	39.4	39.6	39.9	40.2	40.4	40.7	41.0	41.3	41.6	41.8	42.1	42.4	42.7	43.0
40	38.0	38.1	38.2	38.3	38.4	38.5	38.6	38.7	38.8	38.9	39.1	39.2	39.4	39.6	39.8	40.0	40.2	40.4	40.6	40.9	41.2	41.4	41.7	42.0	42.3	42.6	42.9	43.2	43.5	43 8	44.1

Good market milk should have a specific gravity ranging from 1.029 to 1.033 (29 to 33°). A specific gravity differing from this may indicate either skimming or watering, and in such cases the dairy milk supply should be investigated.

The simple determination of the specific gravity above is, however, not decisive. Milk consists of substances which are dissolved in water, and which increase its specific weight, and suspended fat, which decreases its specific weight. A skimmed milk will, therefore, be heavier, and when adulterated with water, may have the same specific gravity as a milk which is rich in cream. To decide in such cases, it becomes, therefore, necessary to make an additional determination of the quantity of fat present.

B.—***Examination of skimmed milk:*** The milk under investigation is brought into a wide vessel (tea cup shape), and allowed to remain in a cool place (to prevent souring) for 24 hours. The cream which has collected on the surface, is then carefully removed, and the specific gravity of the remainder determined. For temperature corrections the second table (for skimmed milk) should be employed.

Unadulterated skimmed milk should have a specific gravity ranging from 1.032 to 1.036 (32 to 36°); specific gravities under 1.032 indicate adulteration with water.

On the basis of this observation Quevenne has given the following table:

A. Whole milk.	*B. Skimmed milk.*	*Water added.*
1.029 – 1.026 (29°–26°) Lactodensimeter	1.032 (32°) Lactodensimeter	10%
1.026 – 1.023	1.029	20%
1.023 – 1.020	1.026	30%
1.020 – 1.017	1.0236	40%
1.017 – 1.014	1.0195	50%

Schrœder and Dietzel found that the specific gravity of the serum of coagulated milk may likewise be used as an indicator for the adulteration with water. A specific gravity less than 1.026 indicates adulteration with water. Further investigations regarding this point are greatly to be desired.

The fact that milk, after such investigations as have been described, does not appear normal, may indicate adulteration, but

this may also be caused by physiological and pathological processes. If, therefore, an exact chemical and physical analysis shows deviation from a normal composition, a milk-dealer can, simply, on this fact, *not be pronounced guilty of adulteration, unless his dairy supply has been shown to be of a normal composition.*

The so-called "stable test" is applied only when sufficient cause for suspicion is given. It consists in a comparison of the properties of the milk produced by the cows, with those of the one which has been sold. The cows, to this end, are milked in the presence of the inspector and witnesses, if possible on the on the same day, or latest, the day after the suspected milk has been found in the market. As it is rarely required to get a thorough knowledge of its composition, the examination is generally confined to the following parts:

1. Determinations of specific gravity of the whole milk by Quevenne's lactodensimeter, reduced to the normal temperature, 15° C.

2. The same, of milk which has been skimmed, after 24 hours' standing.

3. Determination of the fat by means of the lactobutyrometer (not creamometer).

The milking of the cows must be done at the usual hour, and care must be taken that the udders are well emptied. The milk of all the cows thus milked is then mixed. Yet aside of this, and when the time allows, the milk of each cow may be examined separately. It is well to use for the milking of the cows, a disinterested person, to be sure that the udder has been completely emptied. Since, however, it frequently happens that cows milked by strangers yield less milk, it is as well to let the stable attendants milk first and to let the other merely ascertain whether they have done their duty, and if not, to let him complete the milking. The milk which is at first drawn is always more watery than the one drawn last. There is even a difference in the quality of the milk drawn from the different teats. For this reason, and also to insure complete emptying of the udder, the milking is done crossways, milking two teats in diagonal position at a time. Thus the complete emptying of the udder can be best effected.

After all the milk thus obtained has been well mixed, the tests described above are applied. About one pint is taken for subse-

quent chemical examination in the laboratory, which includes, in the first place, an accurate determination of the fat, and determination of the specific gravity of the milk after skimming. Differences in the properties of the milk for sale and the milk thus obtained, indicate the use of adulterants, and the rest of the sample should then be given to a chemist for further examination, to insure a good case when it should be brought before the courts. Water, solids and fat should be determined.

The taking of samples, and the examination in the stable, should be done in the presence of witnesses.

Estimation of the quality of the milk by the specific gravity: The determination of the specific gravity of the whole and skimmed milk, establishes the degree of adulteration by water.

The percentage of fat establishes the fact whether we have a normal or abnormal milk before us.

The percentage of water added may be inferred by the use of the table previously given (p. 83). Whole milk should have a specific gravity ranging from 1.029 to 1.033. If the specific gravity be less than 1.029, the milk must be considered adulterated if a sample taken from the stable should show a different (higher) gravity. If the specific gravity should be found higher than 1.033, it may indicate the partial removal of the cream.

If the milk, skimmed after 24 hours' standing, shows a specific gravity of less than 1.032, while unskimmed its specific gravity appears normal, we conclude that the milk under examination had been skimmed and watered.

The quantity of cream removed is inferred from a

Determination of the Fat.

It is to be regretted that as yet for the estimation of fat in milk, Chevalier's creamometer is frequently used. When using this apparatus, the milk is allowed to stand for 24 hours, after which the amount of cream which has risen to the surface, is determined. The results obtained from this instrument are very uncertain, and should never be used in proceedings before a court of justice, for the following reasons:

1. The cream, even under the same conditions, does not rise evenly.

2. Addition of water to milk makes milk appear richer, for the greater consistency of pure milk prevents the easy formation of cream.

3. The cream rises quicker or slower according to the temperature at which the milk is kept. Moreover, the layer of cream appears larger at lower, and smaller at higher temperatures.

4. Milk frequently sours, and therefore coagulates before the cream has all risen.

5. The manner of transporting the milk influences the process of creaming considerably.

6. The cream constantly varies in percentage of fat. Often it is very rich, then again thinner; sometimes it collects and rises easily, and at other times less completely.

For comparative quantitative fat determinations, it is advisable to use, in the place of the costly creamometer, the simpler and cheaper apparatus of Schatzmann (to be obtained through the "Schweizer Molkerei Versuchsstation, at Lausanne").

The points mentioned above do not influence the results, which may be obtained by means of the improved lactobutyrometric test, whereby the percentage of fat can be determined in milk in from one-half to one hour's time, sufficiently exact, while with Chevalier's creamometer, we are obliged to wait 24 hours before the very unexact results can be obtained.

The results obtainable by the lactobutyrometer are not so exact as those which are obtained by a careful chemical analysis, but sufficiently accurate for the purpose, differing from the truth in the average not more than 0.2 to 0.3 per cent. Small errors do not, however, influence the usefulness of the test, if we consider the value arising from a quick determination of the fat.

The following apparatus are required for the application of this test:

1. Glass rods for stirring the milk.

2. A water bath to prepare water of 40° C., consisting of a high cylinder of metal, which rests on a dish upon which alcohol may be poured and ignited, to heat the water to the required temperature.

3. A glass or metallic cylinder for the water of 20° C.

4. A Centigrade thermometer.

5. A drop glass for potash solution.

6. 3 bottles, one containing ordinary alcohol for burning, another alcohol of 90 to 92° Tr., and the third ether.

7. An alcohometer (Tralles) for testing the alcohol.

8. A tested lactobutyrometer with stopper.

9. Pipettes for alcohol of 90 to 92° Tralles, and ether, discharging 10 c.c. or 5 c.c. when blown out.

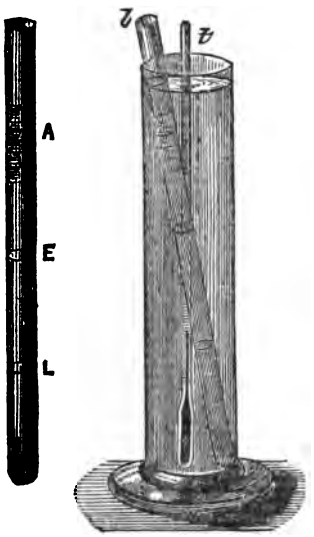
10. Pipettes for milk adjusted to give 10 c.c. or 5 c.c. between two marks or divisions.

The whole lactobutyrometric apparatus is generally for sale put up in a case. (See below "Utensils.")

The principle of the lactobutyrometer is based upon the observation, that alcohol separates from milk which has been mixed with ether, an etheric fat solution, the volume of which stands in an intimate relation to the quantity of fat dissolved in the ether. The method and apparatus were invented by Marchand, and the latter was called by him the lactobutyrometer.

The lactobutyrometer is a tube of equal width throughout (10 to 12 m.m.), closed at one end. From this point on the lactobutyrometer is divided into three equal parts, each being 10 c.c. or 5 c.c. A space equal to about 1 of these parts must remain to allow the contents to be well mixed by shaking. The space between the two upper marks is subdivided into $\frac{1}{10}$ c.c.

While the lactobutyrometer may be used by the inspectors, its results should always be verified by actual analysis, when a case is to be brought before the courts.



Lactobutyrometer.

Determination of Fat by the Lactobutyrometer.

1. The milk must be thoroughly mixed, by shaking the bottle, or otherwise by agitation with a glass rod, immediately before it is sampled. If it should be sour, it must be neutralized or made slightly alkaline with potash solution. The pipette marked milk is then filled with the milk above the mark, by suction; it is then quickly removed from the mouth, and the upper opening closed by the slightly moistened forefinger. By slightly decreasing the pressure, the milk may be made to flow out at the bottom. As soon as the surface of the milk becomes even with the upper mark, the pressure of the finger is again increased, and thereby the outflow stopped. The under end of the pipette is then brought into the mouth of the lactobutyrometer, and the milk allowed to flow out until its surface becomes even with the under mark.

If an ordinary pipette is used with only one mark, the last drop is removed by blowing it out.

2. The pipette marked ether is then filled in a similar manner as described above, with pure ether, and its contents are allowed to flow on the milk in the lactobutyrometer, care being taken that the last drop is brought into the apparatus by blowing it out.

The tube is then closed with a well-fitting cork, and the whole shaken, lifting the cork from time to time, until milk and ether form a uniform liquid. This takes several minutes.

During this time the water of 40° C. may be prepared. The cylinder containing the water is placed upon a dish upon which some alcohol is poured and ignited. The alcohol is allowed to burn until the water has reached a temperature of from 40 to 42° C., which is observed by a thermometer suspended in the water. The alcohol is then quickly extinguished.

3. While yet the water is heating, and after the uniform mixture of ether and milk has been obtained, the third pipette is filled with alcohol, and the alcohol added to this mixture. The shaking of the tube is then continued, opening the cork from time to time, until all lumps have disappeared, and the precipitate, which has been formed, appears finely flocculent. The lactobutyrometer is then put into the cylinder, filled with water of 40° C. After 10 minutes standing, the fat solution has well separated from the rest,

and appears in that part of the tube which is divided into tenths of cubic centimeters.

With the aid of cold water and the water 40° C. warm, water of 20° C. is then prepared, and the lactobutyrometer is inserted into this. There it remains for from one-quarter to one-half hour. The layer of fat is thereby generally yet increased.

Over the solution containing the undissolved albuminates, an etheric fat solution of high refractive power has accumulated, the volume of which is read by means of the divisions on the tube.

To this end, the reading is taken from the lower meniscus at the surface down to the even plane where the lower and upper liquid meet.

The amount of fat corresponding to the tenths of cubic centimeters of solution read, is found in the following tables.

The upper portion of the lactobutyrometer contains 5 c.c. subdivided into tenths, therefore, 50 degrees. Provided the reading at the upper end (lower meniscus) had given 45° = 4.5 c.c., and at the lower end of the fat solution, 31° = 3.1 c.c., the height of the solution would be equal to 14° = 1.4 c.c.

According to the tables we find the amount of fat = 3.991 per cent.

Remark: The cleaning of the milk pipette and the lactobutyrometer is easiest effected in the following manner: Rinse first with concentrated soda solution; then with water, strong alcohol, and ether, successively.

Though this determination of the percentage of fat in milk requires more manipulation and time than Feser's lactoscopic method, it must be considered that this latter instrument is expected to give only satisfactory results, when it is in the hands of men well acquainted with analytical chemistry and the handling of the apparatus. As an easy test to be used by milk inspectors, the lactobutyrometer is, therefore, to be preferred.

It requires neither special knowledge nor expertness in its use, and is, therefore, always to be recommended when it is required to make practically accurate determination in the shortest possible time. The place of an accurate determination of the fat by chemical analysis it can, however, not take; but it will always find its place of usefulness when physicians, inspectors, or dairymen desire to make a fat determination, in case that the lactodensimeter test is insufficient to decide the question of adulteration with certainty.

TABLE GIVING THE QUANTITY OF FAT CORRESPONDING TO THE NUMBER OF TENTHS OF CUBIC CENTIMETERS OF ETHERIC FAT SOLUTION, OBSERVED IN THE LACTOBUTYROMETRIC TEST. According to F. SCHMIDT, *Henneberg's Journal fuer Landwirthschaft*, 1878, p. 381.

Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.	Tenth c.c. of Etheric Fat Solution observed.	Corresponding Quantity of Fat.
1	1.339	6.5	2.461	12	3.583	17.5	4.792	23	7.016	28	9.506	33	11.996	38	14.486	43	16.976	48	19.466
1.5	1.441	7	2.563	12.5	3.685	18	4.956	23.5	7.265	28.5	9.755	33.5	12.245	38.5	14.735	43.5	17.225	48.5	19.715
2	1.543	7.5	2.665	13	3.787	18.5	5.129	24	7.514	29	10.004	34	12.494	39	14.984	44	17.474	49	19.964
2.5	1.645	8	2.767	13.5	3.889	19	5.306	24.5	7.763	29.5	10.253	34.5	12.743	39.5	15.233	44.5	17.723	49.5	20.213
3	1.747	8.5	2.869	14	3.991	19.5	5.483	25	8.012	30	10.502	35	12.992	40	15.482	45	17.972	50	20.462
3.5	1.849	9	2.971	14.5	4.093	20	5.660	25.5	8.261	30.5	10.751	35.5	13.241	40.5	15.731	45.5	18.221	50.5	20.711
4	1.951	9.5	3.073	15	4.195	20.5	5.837	26	8.510	31	11.000	36	13.490	41	15.980	46	18.470	51	20.960
4.5	2.053	10	3.175	15.5	4.297	21	6.020	26.5	8.759	31.5	11.249	36.5	13.739	41.5	16.229	46.5	18.719	51.5	21.209
5	2.155	10.5	3.277	16	4.399	21.5	6.269	27	9.008	32	11.498	37	13.988	42	16.478	47	18.968	52	21.458
5.5	2.257	11	3.379	16.5	4.501	22	6.518	27.5	9.257	32.5	11.747	37.5	14.237	42.5	16.727	47.5	19.217	52.5	21.707
6	2.359	11.5	3.481	17	4.628	22.5	6.767												

Prof. Soxhlet has lately changed the test, in so far as he requires a determination of the specific gravity of the etheric fat solution.

For practical purposes Soxhlet's method is too complicated and costly, on account of the price of the apparatus and the large quantities of ether required. For laboratories it is much to be recommended.

Marchand's improved method gives also satisfactory results, and would, for practical purposes, have to be preferred to Soxhlet's, since the apparatus is less complicated and costly.

Rules regarding the Execution of the Lactobutyrometric Test.

1. Milk, ether, and alcohol must be exactly measured in pipettes, each of which is to be used for one of the fluids only. The fluids must be brought into the lactobutyrometer directly from the pipettes.

2. The lactobutyrometer should be well gauged, as in the case of these instruments like inaccuracies are liable to occur as in the lactodensimeters.

3. A large number of experiments have proved that the strength of the alcohol need not be absolutely of a certain standard. Some propose alcohol of 90° Tr., others 91 and 92° Tr. It is certain that an alcohol of from 90 to 92° Tr. gives the best results, and, while the use of an alcohol of less strength is indicated for richer milks, one of greater strength would be required for the examination of a more watery article.

4. The ether should be very pure 65° = 0.725 specific gravity.

5. The alkali solution should be 36° B., and not more than one drop of it should be used for each 10 c.c. milk. It should never be added to the alcohol and ether mixture, but to the milk before any of these reagents have been added.

Using these precautions in the examination of a whole milk, the results will always be found to be almost accurate. In examining a milk which has been skimmed, the difference is easily perceptible. A milk, which by the use of the lactobutyrometric test, contains less than 3 per cent. of fat in each of two determinations, should be examined in the laboratory by exact analysis.

Skimming and addition of water become evident from the decrease in fat and increase of water. It is referred here to the

table previously given on skimmed milk and its percentage of fat. The inspector's report is to be verified by an exact determination of fat and solids.

Mixing of whole and skimmed milk may be inferred by the data given above.

Foreign substances in milk: The substances most generally applied have been given on pages 41–43. Also the methods used for their detection.

Properties of Normal Cows' Milk and Market Milk.

Normal cows' milk and milk of commerce must possess an agreeable normal odor and taste—*i. e.*, it should not emit a disagreeable odor or possess an alkaline or sour taste. The whole and normal milk of commerce, obtained by mixing the milk of a number of cows, has an average composition as follows:

Water and volatile substances	87.5 per cent.
Salts	0.5 "
Fat	3.5 "
Albuminates	4.0 "
Milk sugar	4.5 "

Its average specific gravity, according to many thousands of experiments, ranges from 1.029 (29°) to 1.033 (33°). It contains in the minimum 3 per cent. of fat and 12.5 per cent. total solids.

For good and normal cows' milk, these points constitute an indisputable truth. Each milk which does not come up to this standard is a poor article.

11 per cent. of solids, 2 to 1½ per cent. of fat, and a specific gravity of from 1.031 to 1.035, indicates that such milk has suffered the loss of one-half its cream.

9½ to 9 per cent. solids, 1 to ½ per cent. fat, and a specific gravity of from 1.0325 to 1.036, indicates that the milk is skimmed entirely of its cream.

The Aim of Governmental Control of the Quality of the Milk Supply.

The inspection of the milk brought upon the market aims not only at the detection of the adulterations, but must be instituted to guarantee to the public that the article which they receive is of

undoubtedly good quality. That the measures used for its dispensation are correct, should likewise fall within the scope of the examination. Aside of real adulterations, many other changes occur which are of importance, and which are caused either by sickness, inadequate food and treatment of the animals, but also by the careless handling of the milk.

For the detection of the first-mentioned causes, the health authorities should confer with a veterinarian.

The question arises here whether producers of an inferior article should not be prevented from selling their milk, and should instead be held to find another application for such milk.

The interest of the public undoubtedly demands that we insist upon such restriction, especially since our advanced knowledge enables the farmer to remedy, by rational treatment, any abnormalities thus discovered. If, therefore, any man has made it his business, for the sake of its profitability, to supply milk, he should also be held to bestow all necessary care upon the production of a good article, in the same way as it is exacted from the producers of other food.

One of the best safeguards would be, if the dealers were strictly held to sell their milk for what it is, ***whole milk, half skimmed, and wholly skimmed*** milk, with gradation of prices accordingly, and that not, as is generally done, they exact the same price, irrespective of quality. The sale of a milk at a higher price than would correspond to its grade, should be considered a fraud. *Ordinances to this effect would prevent much wrong-doing, many prosecutions, and also much unnecessary expense of time and money for the entertainment of a large force of milk inspectors.*

Prof. Dr. I. Feser, of Munich, an authority in this branch, says: "The farmer is compelled to remedy existing evils if he is com- "pelled to bring a normal article to market. But I desire to call "attention to the fact, that it is equally desirable to prevent the "sale of milk which is below a certain standard as good milk, even "if it be simply the unadulterated product of single animals re- "duced through insufficient and faulty feeding. The inspection "is, therefore, not only instituted to prevent adulteration, but like- "wise for the exclusion of an article of inferior value. Ordinances "passed for the prevention of adulteration would be powerless, if "it be lawful that milk may be adulterated before its production, "in the body of the animal, by injudicious treatment and feeding."

R. Schatzmann, in Lausanne, says: "It is not clear, why, at the "present day, the sale of skimmed milk should in many places be "interdicted. Everybody knows that cream and butter are sold "by the same parties who profess that they send so-called good "milk to market. Thus restrained, many producers are led to "commit a fraud, as they may not be able to utilize the skimmed "milk in their own household or for the manufacture of cheese. "And why should the public be prevented from buying a yet ex-"cellent food, if it can be had at a lower price? The producers "will then not be compelled to commit a fraud, nor will the con-"sumer be defrauded, when he pays for skimmed milk as such."

Milk-dealers should, therefore, be held to sell their goods for what they are, and at prices ranging according to their quality.

For larger cities, ordinances to this effect would be of considerable value, especially as it is, in such cases, frequently impossible to examine the milk at its source. Each dealer in food must know the quality of the article he sells, and if defrauded himself, he is not less liable if he defrauds others.

General Rules for a Rational Milk Inspection.

A.--IN CITIES.

1. The inspection includes the milk as furnished by the producers as well as the dealers.

2. At the inspection *at the place of sale*, the following points should be observed:

a. Cleanliness in the handling of the milk and the vessels in which it is carried. For transportation as well as storage the use of only such vessels should be permitted, which allow an easy and thorough cleaning. They should have, therefore, sufficiently wide openings. They should neither be made of copper nor zinc, and should not be kept in places which are used as dwelling rooms, or in such places where garbage or other bad smelling substances are near.

b. The correctness of the measure for retail sales should be verified.

c. Note should be taken of the quantity of the milk brought to market, and the number of cows which have contributed to this

supply, since it frequently happens that the figures thus obtained are quite out of proportion.

d. Examine appearance, odor, taste, and reaction. A strongly alkaline or acid milk, or one with bad taste, should be confiscated. The use of preservatives should be considered an adulteration.

e. Determination of temperature to ascertain whether heat has been applied to preserve the milk. A temperature of over 35° C. would indicate that such has been done.

f. Statements as to quantity and price of the milk.

g. Each sample taken is given a number, and on the record book the following facts must be stated:

Name of seller.

Occupation of same (producer or dealer).

Age of same, and residence.

If the seller be merely dealer, he must state name of producer, and number of cows kept by the same.

h. The sampling of suspicious milk is done after it has been well mixed by a dry and clean rod. One-half liter is then bottled, sealed, and labeled in the presence of witnesses. The label on the bottle gives merely the number under which the sample has been entered in the inspector's book, to avoid that the chemist may be charged with partiality. The samples should be paid for, and, on demand, a similar sample, sealed and labeled, should be prepared for the dealer, that he may have an analysis made at his own expense.

3. At the laboratory the following tests are made:

If a sample is to be forwarded to an expert at some distance, it is well to insert the bottle containing it into boiling water for one-half or one hour. It is then sealed and labeled. Milk thus treated will bear transportation easily without souring.

a. Determination of the ***reaction*** of the milk with litmus or turmeric paper.

b. *Boiling of the milk* when strongly acid.

c. Determination of the *specific gravity* by means of an accurate Quevenne's lactodensimeter, on the fresh milk, and on the milk skimmed after 24 hours standing.

d. Determination of the fat by means of an accurate improved Marchand's lactobutyrometer, or by some other sufficiently accurate method (the creamometer cannot be counted amongst these).

e. Determination of solids by approved chemical method.

The accuracy of the apparatus is of the greatest importance, and the utmost pains should be taken to insure it. It would be well, if from the part of the government, steps be taken to insure that only accurate instruments be brought into the market, by appointing a person, whose duty it shall be to test and mark all such instruments which have stood the test. That the instruments, which are sold without this precaution, are almost without exception incorrect, is a notorious fact.

The work of verifying the correctness is by no means an easy task, and should be given into proper hands.

B.--IN THE STABLE.

The stable test, which can be easily made in smaller cities and villages, is frequently not applicable in larger cities, owing to the distances from which the milk is brought. In such cases an ordinance binding the dealer to sell the milk only under such names as indicate its real character, should be substituted.

Wherever the stable test can be made, and is in use, the following rules should be observed.

a. The milking is to be done, if possible, at the usual time and with the assistance of a disinterested person.

b. The specific gravity is determined by means of the lactodensimeter, at a temperature as near as possible to 15° C.

c. The reaction of the milk is taken.

d. Samples of about 1 pint are taken for the determination of the fat and specific gravity of the milk skimmed after 24 hours standing.

e. The number of cows, their age, period of lactation, health and feed, etc., are to be noted.

f. The book stating the sales during two weeks past, is to be examined, and thus the quantity ascertained compared with the quantity of milk obtained at the time of examination.

g. General information from attendants as to the feeding of the cows, handling of milk vessels and milk, and quantities of milk used for obtaining cream, is also to be obtained.

The correctness of the notes taken is to be verified by the signature of a witness.

Proposition Stating the Main Points for an Ordinance Regulating the Sale of Milk in Large Cities.

For the protection of the public against fraud and injury to health, the following points suggest themselves.

1. All dealers in milk should be licensed, and licenses be granted only to responsible parties. The sale of milk by unlicensed parties is prohibited.

2. A record should be kept of the names, residences and places of business of all licensed dealers.

3. Dealers should be acquainted with the use of the lactodensimeter, lactobutyrometer and litmus paper.

The government should aid this education by free lessons and printed statements explaining the use of these instruments.

4. Only fresh milk should be brought to market, and it should not be sold under the general denomination of "milk," but from vessels marked clearly and in large letters, at a part easily seen, stating their contents as:

Whole milk.
Milk half creamed.
Skimmed milk.

5. Excluded from sale be all milk from cows sick with pulmonary fever, anthrax, tuberculosis, and aphtha epizootica (hoof and mouth disease), likewise, bitter, salty, mucous, abnormally colored, spoiled or adulterated milk.

6. The greatest cleanliness shall be observed regarding the vessels and measures for the milk, as well as the stores, which must be airy, dry and cool, and which should in no wise be used whereby the purity of the milk be endangered. It should never be kept in places used for sleeping rooms.

7. Inspectors are entitled to take samples from all stores or other places where milk is sold, against receipt or payment.

8. The inspection must always be done in the presence of at least one witness, who must countersign the record.

Propositions for Regulations Governing Producers of Milk and Milk-Dealers.

The farmer should know what he brings to market. M. Fleischmann says with reference to this:

"The farmer, whose intention it is to better himself by bring-
"ing his husbandry upon a rational basis, must know the value of
"his cows. To this end he requires aids which allow him, without
"being a scientist himself, to ascertain whether the milk of cer-
"tain cows be watery or rich in solids, and what the yield of
"cream is in special cases. He is more interested in comparing
"one milk with another, than in knowing the actual difference by
"percentage."

Considering this, it cannot be considered as asking too much if it be required that farmers and dairymen should be held to regulations as follows:

a. Strict supervision over the cattle, stables and feed.

b. Occasional examination of the milk of single cows, and the yield of all mixed, with the aid of the lactodensimeter, Schatzmann's cream test or lactobutyrometer.

c. Abnormal or spoiled milk shall not be sold.

d. Regularity in the time of milking must be observed.

e. The milk is to be properly cooled by putting the vessels containing it in cold water, and stirring it slowly until it has reached the temperature of the water.

f. The cooled milk must be kept in a cool place.

g. The farmer shall keep notes respecting number of cows and daily yield of morning and evening milk.

h. No milk drawn before the eighth day after calving shall be brought to market. Likewise none from sick animals, or such under medical treatment, or of cows which have to be watered with unhealthy stagnant water.

i. The greatest cleanliness must be practiced during milking, storing, or transporting the milk.

Considering the consequences wrought by adulterated or otherwise unhealthy milk, upon the health of consumers, it is certainly not asking too much if, in the interests of humanity, exemplary punishment for this crime is demanded, and that, especially, the highest punishments which are possible under the law, be dealt out to such persons, which have been held before for the same offence.

LIST OF APPARATUS AND CHEMICALS REQUIRED FOR THE ANALYSIS OF MILK AND INFANTS' MILK-FOODS.

Blue and red ***litmus paper, turmeric paper, distilled water, absolute alcohol and ether.***

Chemically pure hydrochloric, nitric, sulphuric and acetic acids.

Sulphuric acid of commerce (66° B), and ***calcium fluoride*** in powder, for cleaning platinum vessels.

Dilute sodium or potassium hydrate solution of known strength, to neutralize the hydrochloric acid used for inversion.

Potassium hydrate solution of 1.048 specific gravity (50 potassium hydrate and 1000 water), to neutralize Ritthausens' cupric sulphate solution.

Cupric sulphate solution (63.5 grms. crystallized cupric sulphate dissolved to 1 liter).

Fehling's solution (see page 28).

Uranium solution according to Neubauer, see Fresenius' Quantitative Analysis.

Iodine solution (1 iodine to 50 water).

Phenolphtalein as indicator in volumetric analysis. Dissolve 1 part in 30 parts of alcohol, and use from 1 to 2 drops at a time.

Potassium ferrocyanide solution as a test for copper, in Fehling's volumetric sugar determination.

Glazed paper.

Swedish filter paper, free from ashes, is obtained according to P. T. Austen, by soaking for from 4 to 5 days the filters, which had previously been washed with diluted hydrochloric acid, in a mixture of 30 c.c. concentrated hydrochloric acid, 15 c.c. commercial hydrofluoric acid, and 500 c.c. distilled water. The fluid is then poured off, and the filters are washed with warm water until no muriatic acid reaction is obtained. They are then dried. The following manufacturers prepare paper free from ashes: Schleicher & Schuell, Darren, Prussia; Linke and Rosala, Bruenn.

A fine chemical balance and weights.

Microscope, magnifying power to 400 or 500 linear dimension.

Thermometer (Celsius).

Specific gravity bottle with thermometer, Geissler, in Bonn, Prussia.

Platinum dishes and crucibles with covers and spatules.

Porcelain crucibles with cover, for the incineration of the albuminate copper precipitate.

Glass cylinders with foot, of from 250 to 1000 c.c. contents.

Liter and 1-2 liter flasks.

Several nests of ***beaker glasses.***

Several nests of ***porcelain dishes.***

Glass flasks of from 50 to 500 c.c. contents.

Pipettes of from 5 to 50 c.c. contents divided into $\frac{1}{10}$ c.c.

Burettes, 50 c.c. contents, divided into $\frac{1}{10}$ c.c., with pinch cocks or glass cocks, together with supports of wood or iron.

Wash-bottles for distilled water, alcohol and ether.

Large watch glasses, well fitting, and clamps to hold them. They serve to hold the filters which are to be weighed.

Larger and smaller dessicators, with chloride of calcium or sulphuric acid.

Forceps of wood and of brass, platinum pointed.

Glass rods of various sizes and thickness.

Glass covers.

Feather brushes (black and stiff).

Rubber covered rods for removing precipitates.

Platinum or clay pipe stem triangles.

Ring stands.

Muffle.

Water baths, with rings and covers.

Air bath, with thermometer and temperature regulator.

Water aspirator.

Liebig's coolers and stand.

Areometer, according to Tralles.

Lactodensimeter, with thermometers and glass cylinders. Manufactured by Alt, Eberhard and Jaeger, Ilmenau, Germany, or Greiner and Friedrichs, Stuetzerbach.

Lactobutyrometer, same manufacturers.

Schatzmann's cream tester, R. Schatzmann, Milch Versuchsstation, Lausanne.

Gerber's apparatus for the determination of the fat, Greiner and Friedrichs, Stuetzerbach, also Alt, Eberhardt and Jaeger, Ilmenau, Germany; Frères Alvergniat, rue de la Sorbonne, Paris.

Gerber's set of apparatus for home use and milk inspection, in case, as well as all other instruments used for milk testing, may be obtained from the author. Correctness guaranteed.

LEHN & FINK,

Wholesale Druggists,

IMPORTERS AND EXPORTERS,

No. 160 William Street,

NEW YORK.

We call the attention of the Profession to our **large** and **complete** stock of **strictly pure**

CHEMICALS,

ACIDS,

METALS,

MINERALS,

ALCALOIDS, etc., etc.,

constantly imported direct from the most reliable sources in Europe, in suitable **original packages** to meet the wants of **Laboratories, Manufacturers, Colleges** and **Chemists** in general.

RARE AND NEW ARTICLES A SPECIALTY.

Collections of **Minerals, Alcaloids** and **Physiological Preparations** on hand and imported to order.

Quantity Supplies for **Institutions, Schools,** etc., imported to order at special rates.

All orders will be executed with utmost **care** and **promptness** at **lowest market prices.**

LEHN & FINK,

P. O. Box 3114, N. Y.